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THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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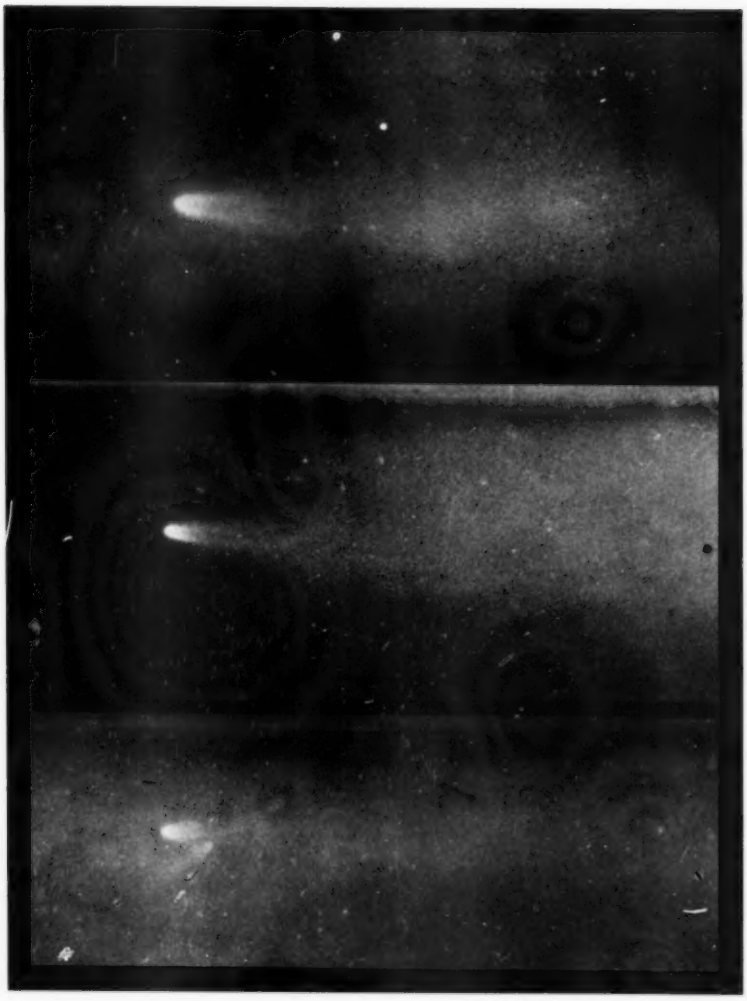
PLATE VIII.

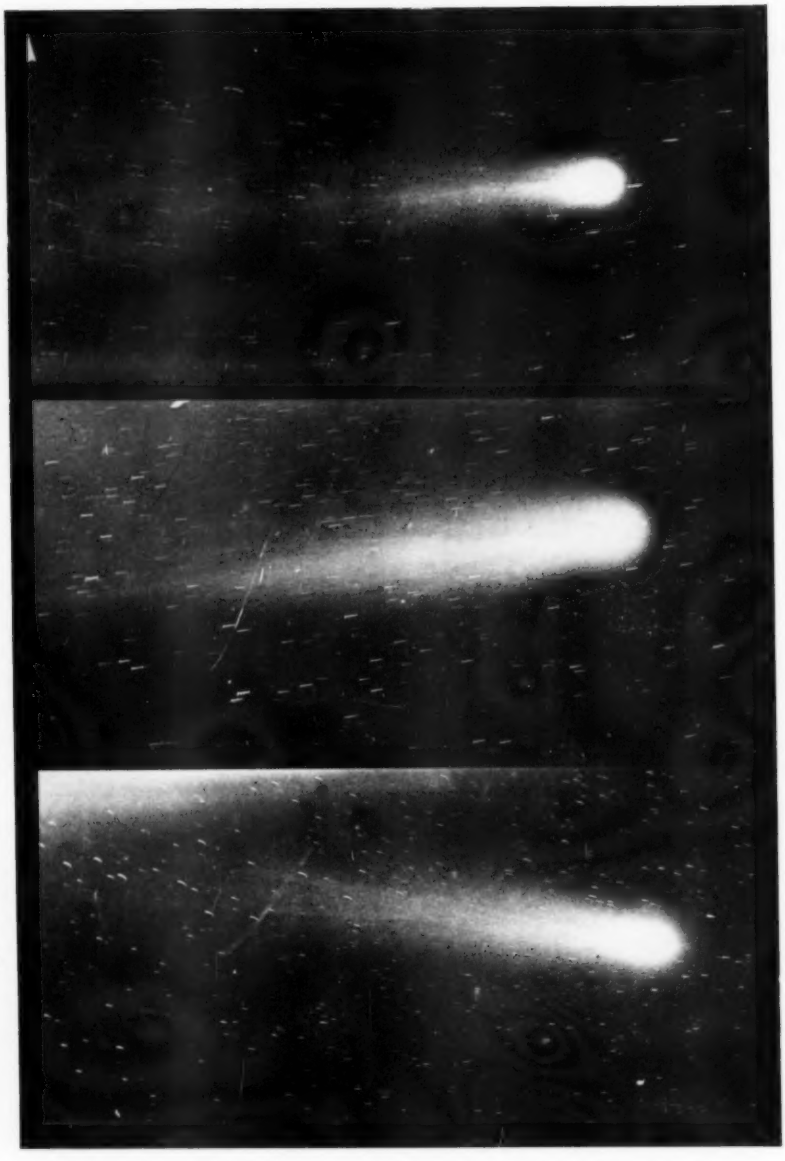


HALLEY'S COMET

Photographs taken at the Dominion Astronomical Observatory, Ottawa.
By R. M. Motherwell. (See page 224).

No. 1, May 3; No. 2, May 5; No. 3, May 9, 1910.

PLATE IX.

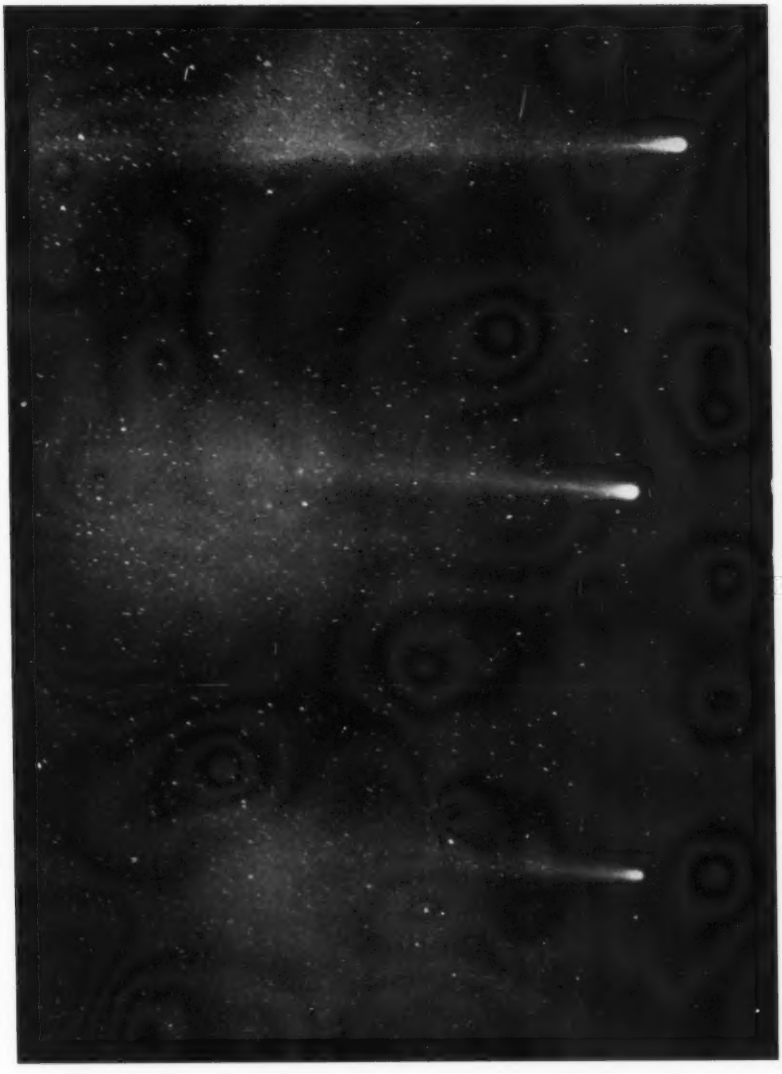


HALLEY'S COMET

Photographs taken at the Dominion Astronomical Observatory, Ottawa.
No. 4, May 27: No. 6, May 28: No. 8, June 3.

Journal of the Royal Astronomical Society of Canada, 1910

PLATE X.

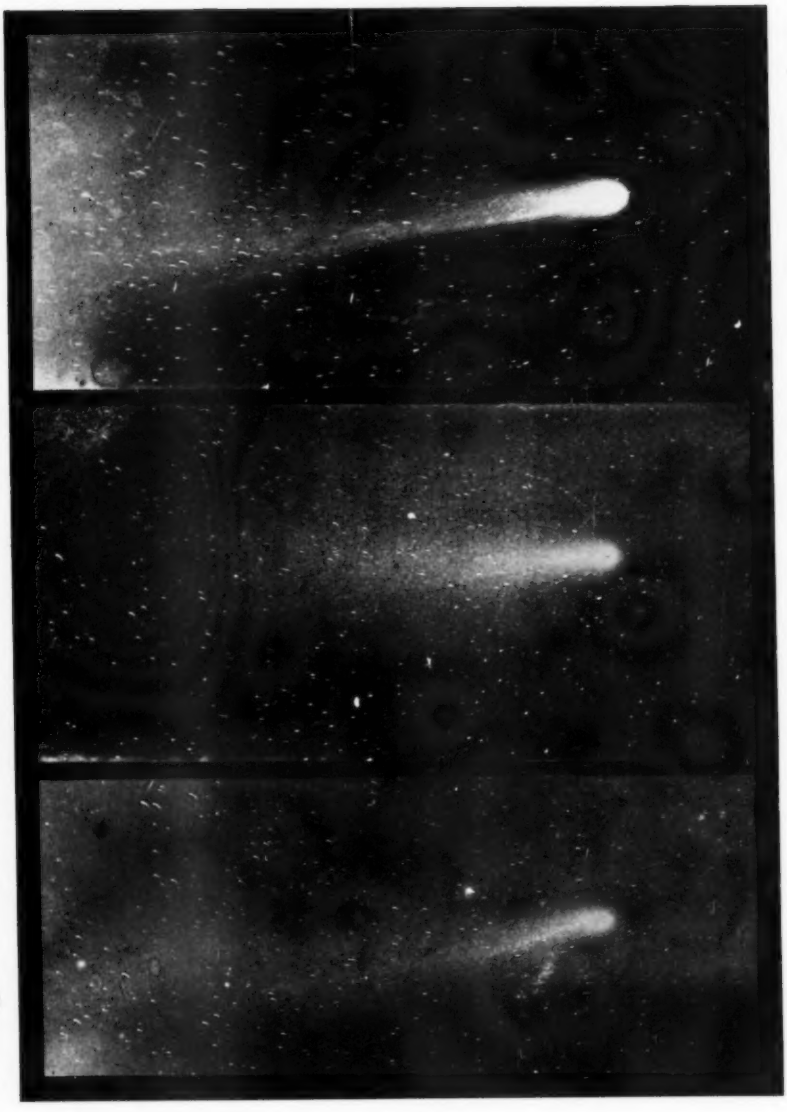


HALLEY'S COMET

Photographs taken at the Dominion Astronomical Observatory, Ottawa.
No. 5, May 27; No. 7, May 28; No. 9, June 3.

Journal of the Royal Astronomical Society of Canada, 1910.

PLATE XI.

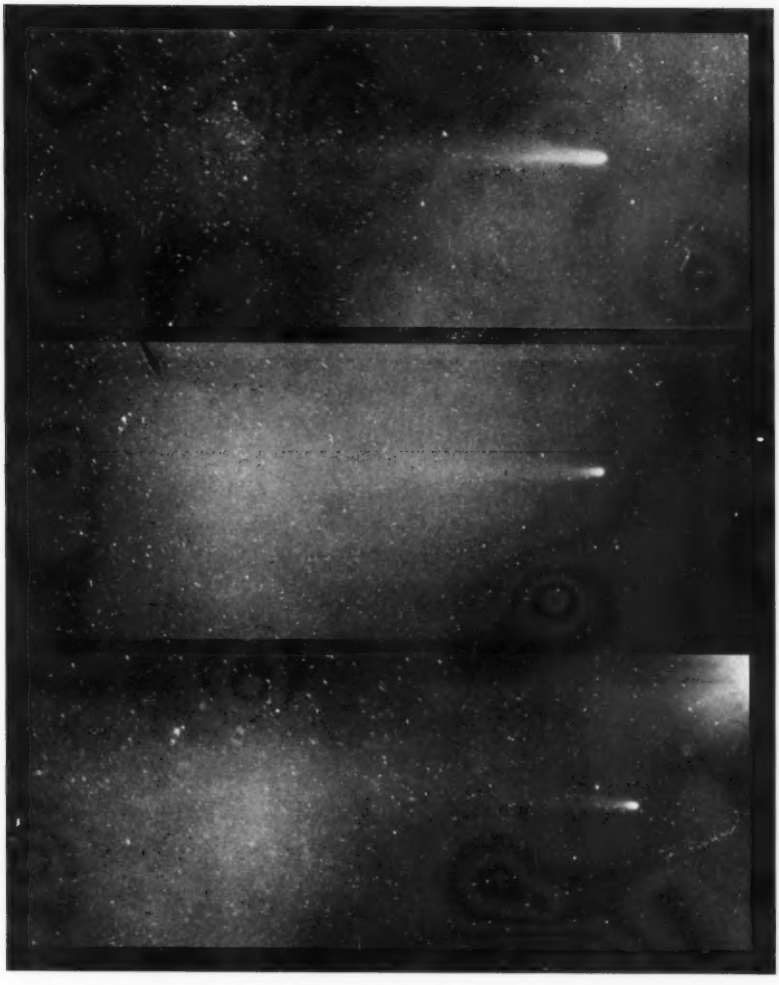


HALLEY'S COMET

Photographs taken at the Dominion Astronomical Observatory, Ottawa.
No. 10, June 4; No. 12, June 8; No. 14, June 9.

Journal of the Royal Astronomical Society of Canada, 1910

PLATE XII.



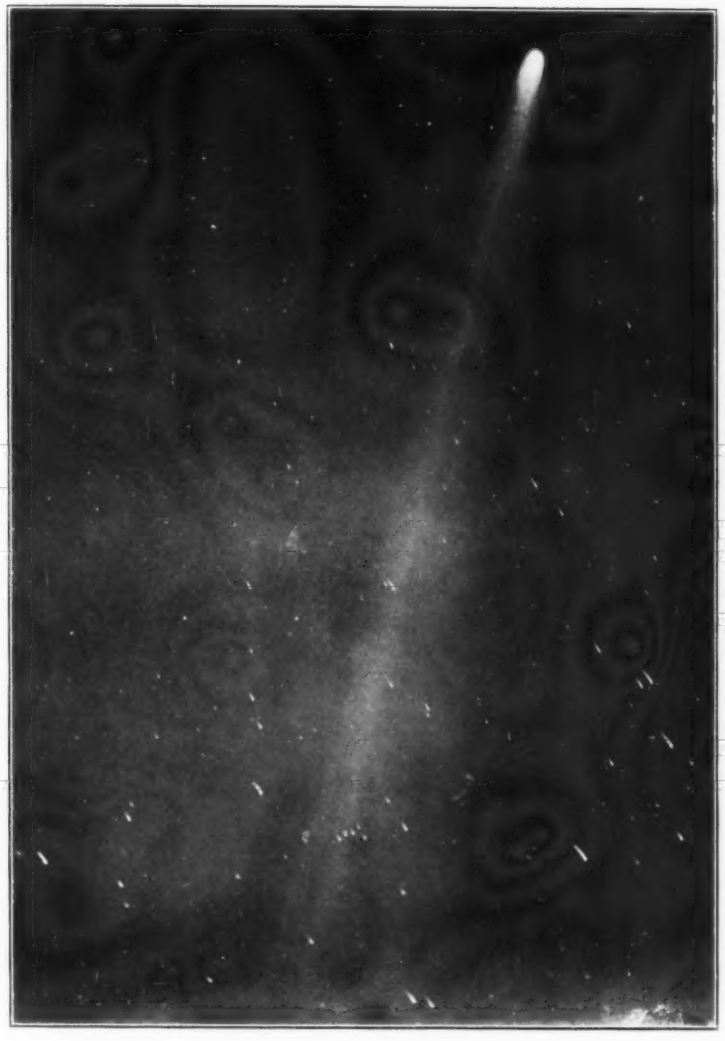
HALLEY'S COMET

Photographs taken at the Dominion Astronomical Observatory, Ottawa.

No. 11, June 4; No. 13, June 8; No. 15, June 9.

Journal of the Royal Astronomical Society of Canada, 1910

HALLEY'S COMET.—Photograph by E. E. Barnard, at the Yerkes Observatory with 3·4-inch lens.
Reproduction same size as photograph. May 5, 1910, 2.49 to 3.20 a.m.
(Length of tail shown on this plate about 20 million miles.)



HALLEY'S COMET.—Photograph by E. E. Barnard, at the Yerkes Observatory with 10-inch Bruce Camera.
Reproduction 3/4 original size. May 5, 1910, at 3.30 a.m. Exposure 40 minutes.

PLATE XV.

HALLEY'S COMET

Photograph taken with a 3-inch camera strapped to 6-inch refractor at the Meteorological Observatory, Toronto, by F. L. Blake.

May 27, 9.14 to 9.55 p.m.

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EARTHQUAKE EPICENTRES

BY OTTO KLOTZ

AS very many earthquakes occur either in uninhabited areas or in the ocean, it is desirable when the disturbance has been world-wide to locate the epicentre. So far no one has succeeded in obtaining an accurate position for the epicentre from a single station except Prince Galitzin of St. Petersburg.

It may be premised that the distance to the epicentre from any earthquake station provided with a sensitive seismograph and good time-scale, can be obtained pretty accurately, provided a good record has been obtained showing the various phases, especially the first and second preliminary tremors, for the speed of the longitudinal and transverse waves which respectively propagate these tremors, is pretty well known for varying distances, the speeds increasing with the depth up to the limit of about 1600 km. depth. The surface or long waves have practically a constant velocity for all distances, being about 200 km. per minute, while the longitudinal waves, which are the fastest, attain a maximum of about 800 km. per minute, and the transverse waves a maximum of about 450 km. per minute.

From the difference of time of arrival of the first and second preliminary tremors we have then sufficient data for giving us the distance to the epicentre. And if we have the distances from three stations, preferably widely separated, the epicentre becomes fixed. However there are always more than three stations available for finding the geographical position of the epicentre or place where the earthquake happened. To find the epicentre we may proceed in different ways. We may employ a large globe and describe circles with radii equal to the respective distances from the different stations, and note their intersections, which will never be exactly at a common point. Or we may solve by least squares which takes considerable time; or lastly, we may obtain the position of the epicentre graphically. This last method it is intended to describe briefly and give a practical application of it for the recent earthquake of January 22, 1910, near Iceland.

The principles of the method involved are well known, being those of stereographic projection; it is simply their application for this particular purpose.

In the stereographic projection, the projecting point is supposed to be at the pole of the primitive circle. In this projection all small circles are projected as circles. This particular feature makes this projection for our purpose available, which would not be the case were the projection an ellipse.

On our sphere we imagine a circle described from each station with a radius equal to the distance to the epicentre, *i. e.*, the epicentre must lie somewhere on the circumference of this circle. Let us for a moment consider the projection in order to find the quantities with which we have to deal.

In the accompanying figure, O is the point of projection, $A\,B$ the trace of the primitive plane upon which the projections are made. P is the station, having the latitude ϕ. $P\,F = P\,E$ are arcual radii or distance to epicentre, the kilometres being converted into arc, (10,000 km. = 90°). $F\,E$ is then the orthographic projection of the small circle about P. This circle pro-

jected on to the primitive plane will cut it in H and K, *i. e.*, $H K$ is its diameter, and the middle point of $H K$, or I is the centre of the projected circle, giving $H I$ and $I K$ as radii. $N I$ is the distance from the pole from which our circle is to be described, as we shall see presently.

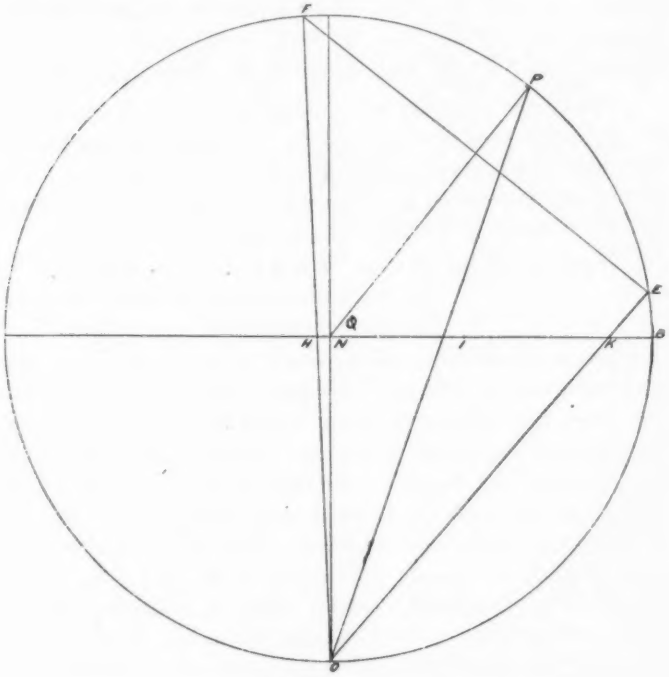


FIG. 1.

$H I$ and $N I$ are the two quantities that we require for the final construction and location of the epicentre,—and as seen above they can be found graphically.

From mathematical considerations, if we call the distance $P F$, $P E$ equal to Δ in arc, $H I$ the radius $= r$, and $N I$ the polar distance $= d$, ($N O$ = unity) then

$$d = \frac{\text{Cos } \phi}{\text{Sin } \phi + \text{Cos } \Delta} \quad \text{and} \quad r = \frac{\text{Sin } \Delta}{\text{Sin } \phi + \text{Cos } \Delta}$$

We shall next proceed to the final construction, using three stations whose geographical co-ordinates are known, taking for illustration the earthquake of January 22, 1910.

Ottawa $\phi = 45° 24'$, $\lambda = 75° 43'$ W, $\Delta = 4120$ km. $= 37° 05'$.
Hamburg $\phi = 53° 34'$, $\lambda = 9° 59'$ E, $\Delta = 2100$ km. $= 18° 54'$.
Cartuja $\phi = 37° 11'$, $\lambda = 3° 36'$ W, $\Delta = 3400$ km. $= 30° 36'$.

Constructing a figure as the preceding one with a radius for the primitive circle of 10 cm. radius, and laying off the latitude accurately as well as the arcual distance Δ or PF and PE; then getting the intersection of OF and OE with AB, we find HI and NI in terms of the radius of the original circle.

We thus find for Ottawa $d = 4{\cdot}65$ cm. $r = 4{\cdot}00$ cm.
Hamburg $d = 3{\cdot}40$ cm. $r = 1{\cdot}85$ cm.
Cartuja $d = 5{\cdot}45$ cm. $r = 3{\cdot}47$ cm.

Now we shall draw another circle with radius 10 cm., and draw three radii in it in their respective positions in longitude, *i. e.*, the angles between the radii express the difference of longitude between the respective stations. On each radius we lay off from the pole the respective distance d, and from this point describe an arc with its corresponding value for r,—thereby obtaining the required intersections. Theoretically the intersections should be at a point, but in practice we find the intersections to form a very small triangle. We take its centre of gravity as the point sought for, the epicentre, measuring from the pole (centre of the primitive circle) to this point and expressing this linear measure in terms of the radius gives us the tangent of $(45° - \frac{1}{2}\phi_0)$, where ϕ_0 is the latitude of the epicentre, for in the stereographic projection the radius of a parallel of latitude is projected into tan $(45° - \frac{1}{2}\phi)$.

From a table of natural tangents we obtain the value corresponding to this tangent, *i. e.*, for $(45° - \frac{1}{2}\phi_0)$. Hence ϕ_0 is found.

For the longitude it only remains to measure with a good

protractor the angle between our initial meridian (Greenwich) and the point found for the epicentre. We thus have found the geographical co-ordinates of the epicentre by a rapid graphical method, with quite satisfactory results, provided the plotting is done with care and not too small a scale is used. From the above we find $\phi_0 = 67° 20'$, $\lambda_0 = 17° 15'$.

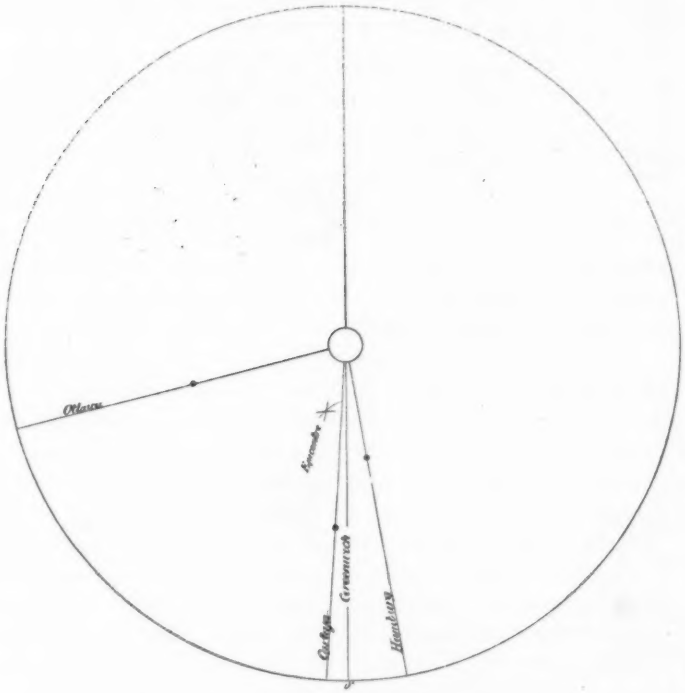


FIG. 2.

EARTHQUAKE JANUARY 22, 1910, NEAR ICELAND

For our purpose at the Observatory we have had special forms printed, each sheet having a circle radius 10 cm., subdivided to half degrees from 0° to 180°, counting from 0° (Greenwich) on each side. These forms serve for each of the processes ;

first to find d and r graphically, and then to find the position of the epicentre.

When this earthquake was plotted more than three stations were used, which gave a slightly greater value for ϕ_0, and of course of more weight. $\phi_0 = 67° 56'$, $\lambda_0 = 16° 45'$. The least square computation by Dr. Tams derived from six stations gave $\phi_0 = 67°{\cdot}9$, $\lambda_0 = 17°{\cdot}1$, practically the same as the above. Prince Galitzin gives for his values derived from the Pulkowa observations alone $\phi_0 = 68°$, $\lambda_0 = 17°$.

As the mathematical determination of d and r by the formulæ given is very readily obtained, some may prefer it to the graphical determination. However for the location of the epicentre we apply d and r graphically.

It is scarcely necessary to say that attention must be paid to the signs (positive or negative) for the two hemispheres.

DOMINION OBSERVATORY,
OTTAWA, CANADA,
March 6, 1910.

THE LOCATION OF THE POLE

By Louis B. Stewart

IN the determination of geographical positions in the neighbourhood of the pole there are various problems and difficulties that arise, requiring a special treatment, which do not occur in lower latitudes. Some of these are of a geometrical character and may, therefore, be investigated by anyone who is conversant with the principles of geodetic astronomy, though unfamiliar from personal experience with all the conditions, climatic and otherwise, which obtain in the Arctic regions. It is proposed in the present article to examine some of these problems and to suggest a method, which appears to the writer the best, for locating the position of the pole, assuming that the explorer desires to determine its position with all the precision that the instruments at his disposal will permit.

In the first place the minimum instrumental equipment for the astronomical work of the Arctic explorer must include an instrument for measuring altitudes, and a good time-keeper. The latter should be a well-adjusted lever watch, regulated to show the time of some known meridian, and its principal use would be to give Greenwich time in using the *Nautical Almanac*. Chronometers are ill-adapted for standing the vicissitudes of sledge-travel, and are soon rendered useless. The former instrument may be either a small theodolite or a sextant, preferably a theodolite ; for, indispensable as the sextant is to the navigator, it is not the best instrument for the explorer, as there are circumstances under which its use may become very difficult if not impossible. In measuring an altitude with it recourse must be had to either an artificial horizon or the natural horizon, the former very inconvenient for observing low altitudes, the latter liable to be obscured by haze even when the sun is bright enough

for observation. The theodolite, on the other hand, contains its own horizon, and can be used equally well at all altitudes.

In finding the geographical co-ordinates of a point within the Arctic circle, while the determination of latitude should present no special difficulty, the accurate determination of azimuth or time becomes more and more difficult as the latitude increases, and each finally becomes indeterminate, as is evident on general considerations. The explorer, however, in quest of the pole, is not interested in the question of longitude, unless new land is discovered, and depends upon the compass needle to guide him in the proper direction.

Coming first to the determination of latitude, the method by meridian altitudes being the simplest, is the one naturally used. In applying this method a knowledge of the direction of the meridian is unnecessary, as the maximum altitude of a heavenly body is also, generally speaking, the meridian altitude. This statement is not strictly accurate in the case of a body like the sun whose declination is continually changing; as such a body if moving north will attain its greatest altitude shortly after passing the meridian; and shortly before if moving south. This applies to the northern hemisphere. The error, however, involved in treating the maximum altitude as the meridian altitude is quite inappreciable, when using small portable instruments, in any but extremely high latitudes. To shew this we proceed as follows:

Let—

δ = the sun's declination at the time of its greatest altitude.

ζ = its zenith distance,

φ' = the resulting latitude;

then φ' is given by the equation

$$\varphi' = \delta + \zeta \qquad (1)$$

and the error of this result is very small. The true value of the latitude, however, is given by the relation.

$$\cos \zeta = \sin \varphi \sin \delta + \cos \varphi \cos \delta \cos t \qquad (2)$$

in which t is the hour angle corresponding to the maximum altitude. As t is small this may be written

$$\cos \zeta = \sin \varphi \sin \delta + \cos \varphi \cos \delta \left(1 - \frac{t^2}{2}\right)$$

$$= \cos (\varphi - \delta) - \cos \varphi \cos \delta . \frac{t^2}{2}$$

or by (1)

$$\cos (\varphi - \delta) - \cos (\varphi' - \delta) = \cos \varphi \cos \delta . \frac{t^2}{2}$$

or

$$- 2 \sin \tfrac{1}{2} (\varphi + \varphi' - 2\delta) \sin \tfrac{1}{2} (\varphi - \varphi') = \cos \varphi \cos \delta . \frac{t^2}{2}$$

or very nearly

$$\varphi - \varphi' = - \frac{\cos \varphi \cos \delta}{\sin (\varphi - \delta)} \frac{t^2}{2}$$

$$= - \frac{1}{\tan \varphi - \tan \delta} \frac{t^2}{2} \qquad (3)$$

To find t we have by differentiating (2) with respect to t

$$- \sin \zeta \frac{d\zeta}{dt} = (\sin \varphi \cos \delta - \cos \varphi \sin \delta) \frac{d\delta}{dt}$$

$$- \cos \varphi \cos \delta \sin t.$$

Then as h is a maximum ζ is a minimum, and $\therefore \frac{d\zeta}{dt} = 0$, and this expression reduces to

$$\sin t = (\tan \varphi - \tan \delta \cos t) \frac{d\delta}{dt},$$

or as t is small

$$t = \frac{d\delta}{dt} (\tan \varphi - \tan \delta). \qquad (4)$$

To find an expression for $\frac{d\delta}{dt}$ let

$\Delta\delta$ = the hourly variation of the sun's declination, expressed in seconds of arc,

a quantity given in the *Nautical Almanac*, then

$$\frac{d\delta}{dt} = \frac{\Delta\delta}{3600 \times 15}$$

so that

$$t = \frac{\Delta\,\delta}{54000}\ (\tan\varphi\ -\ \tan\delta). \qquad (5)$$

To express t in second of time we must divide this by 15 arc 1″; and as

$$\text{arc } 1'' = \frac{\pi}{180 \times 3600},$$

the expression (5) finally becomes

$$t = \frac{4}{5\,\pi}\ \Delta\,\delta\,(\tan\varphi\ -\ \tan\delta), \qquad (6)$$

t being in seconds of time.

Substituting now the value of t given by (5) in equation (3) we have

$$\varphi\ -\ \varphi' = -\left(\frac{\Delta\,\delta}{54000}\right)^2 \frac{\tan\varphi\ -\ \tan\delta}{2 \text{ arc } 1''} \qquad (7)$$

$\varphi\ -\ \varphi'$ being in seconds of arc. Taking logarithms of constant terms we have

$$\varphi\ -\ \varphi' = [5{\cdot}54861]\ (\Delta\,\delta)^2\,(\tan\varphi\ -\ \tan\delta). \qquad (8)$$

From this expression it is evident that the error increases as the latitude increases and the declination diminishes. Moreover, $\Delta\,\delta$ is a maximum when $\delta = 0$, and becomes evanescent as δ reaches its maximum value. Assuming that $\delta = 0$ and $\Delta\,\delta = 59''{\cdot}29$, we find the following values of $\varphi\ -\ \varphi'$ for assumed values of φ :

φ		$\varphi\ -\ \varphi'$
°	′	″
85	00	1·4
88	00	3·6
89	00	7·1
89	30	14·2
89	40	21·4
89	50	42·7
89	55	85·5

These are, of course, extreme values, and the larger ones must be regarded as approximations only, owing to the assumptions made in deriving equation (8) ; but they serve to shew

that although the error is negligible in all but extreme latitudes, it may assume considerable importance as the latitude approaches its limit, and will finally cause the failure of the method. Added to this is the difficulty that in the case of the north pole, that much coveted point is situated in the middle of an ocean covered by an ice-field that is continually in motion, so that the determination of the position of the pole at any instant, by the ordinary methods, to within two or three miles, becomes an impossibility.

This fact, of course, is not of any practical importance, as an explorer whose observations shew that he had arrived at a point within a mile or two of the pole is justly entitled to the honour of having reached that point. A single observation, however, would be insufficient to prove that fact, unless precautions had been taken to insure the altitude observed being the maximum, or the observation being taken on the meridian. On account of the narrowing of the intervals between the meridians as the pole is approached it would be quite possible for an explorer, while supposedly travelling along a given meridian, to be in reality several degrees from it. A degree of longitude in latitude 88° is only 2·4 miles in length. If an observer then were to depend upon his watch to give the time of culmination of the sun, he might observe that body when really far from his meridian; and if the observation were taken near the prime vertical his resulting latitude might be 90°, though he is still some distance from the pole. This is, of course, an extreme supposition, but it shews that the only sure test of position would be secured by observing a number of altitudes at considerable intervals of time or azimuth. At the pole the altitude of the sun — after applying the usual corrections — would always equal its declination, and several altitudes, observed at widely differing azimuths, and each equal to the sun's declination at the time of observation, would furnish conclusive proof that the pole had been reached.

As a problem of purely theoretical interest a method will now be given by which the position of the pole, with reference to the

point of observation, may be determined, whether that point is fixed or in motion, by observing a number of altitudes of the sun with a theodolite, and also the azimuth intervals, the observations covering as wide a range as possible in azimuth. Before doing so, however, a few further remarks must be made on the subjects of longitude and azimuth.

Any method of determining longitude involves observing some quantity or phenomenon from which the Greenwich time can be obtained, and at the same instant finding the local time. The longitude being the difference of these times, is affected by any error committed in determining the latter, in addition to the error in the Greenwich time. The only method available for finding local time is by an altitude of the sun, which should be observed as near the prime vertical as possible, as then unavoidable errors of observation have the least effect. The same data will also give the azimuth of the sun at the instant of observation. Even under these most favourable conditions, however, the errors in the time and azimuth vary respectively as the secant and tangent of the latitude; or, if dt and dA represent these errors and dh the error in the altitude, then

$$dt = -\sec\varphi\, dh,$$
$$dA = \tan\varphi\, dh,$$

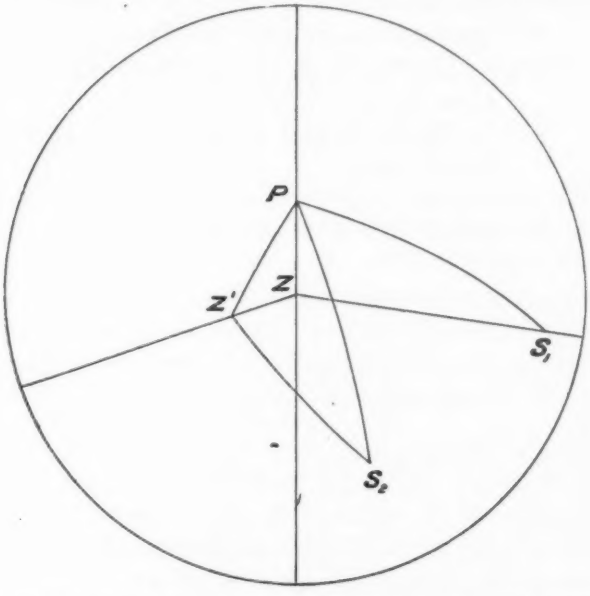
and if the sun is far from the prime vertical the errors will greatly exceed the values given by these formulæ. Taking dh to be 1′ the following table gives the values of dt and dA for assumed latitudes:

φ		dt		dA		
°	′	m	s	°	′	″
85	00	0	45·6		11	26
86	00	0	57·6		14	18
87	00	1	16·2		19	05
88	00	1	52·6		28	38
89	00	3	49·2		57	17
89	20	5	43·8	1	25	54
89	40	11	27·5	2	51	53
90	00	∞		∞		

which shew that the accurate determination of longitude or azimuth is an impossibility in these latitudes.

It is to be remarked that as the length of an arc of a parallel of latitude, expressed in a linear unit, varies as the cosine of the latitude, consequently the error in longitude due to this cause, expressed as a distance, is the same in all latitudes, assuming that the observations are taken very near the prime vertical.

Coming now to the problem above proposed we will assume that an explorer having reached a point within a few miles of the



pole, wishes to determine the direction of, and the distance to that point. Having set up his theodolite he directs the sight line to the sun, reads both circles and notes the time. Then keeping the horizontal circle clamped he repeats this observation at convenient intervals for several hours. In pointing to the sun it may be assumed that he brings the sun's image into contact at the same instant with the horizontal and vertical threads of the

telescope, so that the altitude of the sun's centre may afterwards be deduced by applying to the vertical circle readings, corrections for index error, refraction, semi-diameter, and parallax. The horizontal circle readings of the sun's centre may be found by correcting the observed readings by the quantity

$$S \sec h$$

where

S = the sun's angular semi-diameter, and

h = its altitude.

If in addition—

A = the sun's azimuth at the first observation,

a = the difference between the horizontal circle readings at the first and any other observation,

c = the angular distance of the point of observation from the pole,

and if in the diagram Z is the observer's zenith, P the pole, and S_1 the position of the sun, at any one of the observations; then the triangle $Z P S_1$, gives

$$\sin \delta = \sin h \cos c + \cos h \sin c \cos (A + a).$$

If we assume that c is so small that the square of its radian measure may be neglected, this may be written

$$\sin \delta = \sin h + c \cos h \cos (A + a).$$

Then if we write

$$d = h - \delta \text{ or } h = \delta + d, \tag{9}$$

d is a quantity of the same order as c and we have

$$\sin h = \sin (\delta + d) = \sin \delta + d \cos \delta,$$

so that our equation becomes

$$0 = d \cos \delta + c \cos h \cos (A + a).$$

Then expanding $\cos (A + a)$ and writing

$$c \sin A = x, \qquad c \cos A = y, \tag{10}$$

this becomes

$$- x \sin a + y \cos a + d \cos \delta \sec h = 0. \tag{11}$$

Each observation will furnish an equation of this form, and there being two unknowns any two of the equations will serve, theoretically, to determine those quantities. The best selection would probably be two equations resulting from observations differing by about 90° in azimuth, one of them containing the greatest or least altitude. Two or three such selections might be made and the mean of the results taken.

The best mode of procedure, however, would be to combine all the equations by the method of Least Squares, finding in that way the most probable values of the unknowns resulting from all the equations; though the writer can quite believe that Least Square reductions, while sitting in the lee of an ice-hummock, are not popular with Arctic explorers.

Having determined x and y, c and A follow from (10), thus

$$\tan A = \frac{x}{y}, \quad c = \frac{x}{\sin A} = \frac{y}{\cos A}, \qquad (12)$$

the quadrant in which A is situated being determined by the algebraic signs of x and y, c being assumed to be positive.

On attempting to apply this solution to the conditions which are found to exist near the North Pole, the method is clearly inapplicable on account of the drift of the ice-sheet upon which the observer would be obliged to take his observations. The method may be adapted to these conditions, however, and modified so as to determine in addition to the unknowns of equation (11) also the direction and rate of motion of the point of observation.

Assuming that the direction of drift of the observer's position during the observations is in a straight line, his zenith will describe an arc of a great circle, represented by ZZ' in the diagram. Also if S_1 is the position of the sun at the first observation, and S_2 that at any other observation, and if in the interval the observer's zenith has moved from Z to Z', the horizontal circle of the theodolite will now indicate the difference between the angles which the arcs $Z'S_2$ and ZS_1 make with ZZ', but not the total change in the sun's azimuth between the two obser-

vations ; account must also be taken of the change in the angle between the observer's meridian and the arc ZZ'.

We shall first find expressions for the changes of polar distance and azimuth as a point moves from Z to Z'. Let

c' = the arc PZ',
β = the azimuth of ZZ' at Z,
β' = its azimuth at Z',
b = the arc ZZ',

then in the triangle PZZ' we have

$$\cos c' = \cos c \cos b + \sin c \sin b \cos \beta.$$

Then expanding, and neglecting powers of c' c and b above the second, we have

$$1 - \frac{c'^2}{2} = \left(1 - \frac{c^2}{2}\right)\left(1 - \frac{b^2}{2}\right) + bc\cos\beta,$$

which becomes

$$c'^2 - c^2 = b^2 - 2bc\cos\beta$$

or

$$c' - c = \frac{b^2 - 2bc\cos\beta}{2c} = -b\cos\beta$$

very nearly, or

$$c' = c - b\cos\beta, \tag{13}$$

assuming that b is small in comparison with c.

Again, we have

$$\frac{\sin\beta'}{\sin\beta} = \frac{\sin c}{\sin c'},$$

or writing

$$\beta' = \beta + \Delta\beta,$$

we have

$$\frac{\sin(\beta' + \Delta\beta)}{\sin\beta} = \frac{\sin\beta + \Delta\beta\cos\beta}{\sin\beta} = \frac{c}{c'}$$

or

$$1 + \Delta\beta\cos\beta = \frac{c}{c - b\cos\beta} = \frac{1}{1 - \frac{b}{c}\cos\beta} = 1 + \frac{b}{c}\cos\beta$$

very nearly, therefore,

$$\Delta\beta = \frac{b}{c}\sin\beta. \tag{14}$$

Then, again, in the triangle $PZ'S_2$ we have

$$\begin{aligned}\sin\delta &= \sin h\cos c' + \cos h\sin c'\cos(A + a + \Delta\beta),\\ &= \sin h\cos(c - b\cos\beta)\\ &\quad + \cos h\sin(c - b\cos\beta)\cos(A + a + \Delta\beta),\\ &= \sin h + \cos h\,(c - b\cos\beta)\cos(A + a + \Delta\beta),\end{aligned}$$

or

$$0 = d\cos\delta\sec h + (c - b\cos\beta)\cos(A + a + \frac{b}{c}\sin\beta).$$

Then expanding, multiplying out, and neglecting terms of the second order, this becomes

$$\begin{aligned}0 &= d\cos\delta\sec h + c\cos(A + a)\\ &\quad - b\cos\beta\cos(A + a) - b\sin\beta\sin(A + a).\end{aligned}$$

Then again expanding and re-arranging we have

$$\begin{aligned}0 &= d\cos\delta\sec h + c\cos A\cos a + c\sin A\sin a\\ &\quad - b\cos(\beta - A)\cos a - b\sin(\beta - A)\sin a.\end{aligned}$$

If now t is the elapsed time in hours since the first observation and r is the rate of drift per hour, we have

$$b = r\,t,$$

and if we substitute in the last expression

$$\begin{aligned} c\sin A &= x, & r\sin(\beta - A) &= z,\\ c\cos A &= y, & r\cos(\beta - A) &= u, \end{aligned} \tag{15}$$

it becomes

$$\begin{aligned}&- x\sin a + y\cos a - z\,t\sin a - u\,t\cos a\\ &+ d\cos\delta\sec h = 0.\end{aligned} \tag{16}$$

This is the form of the equation furnished by each observation, and four such equations are now required to determine the values of the unknowns. We may assume that they and the quantity d are expressed in minutes of arc. From (15) we have

$$\tan A = \frac{x}{y}, \quad c = \frac{x}{\sin A} = \frac{y}{\cos A},$$

$$\tan(\beta - A) = \frac{z}{u}, \; r = \frac{z}{\sin(\beta - A)} = \frac{u}{\cos(\beta - A)}. \tag{17}$$

which determine A and β, c and r when x, y, z and u have been found.

If $r = 0$ then equations (16) and (17) reduce to (11) and (12).

In the above investigation it is assumed that b is small in comparison with c. If the point of observation, however, is very near the pole, and the rate of drift considerable, this assumption cannot be made, and the method would require modification ; but the problem is not of sufficient practical importance to warrant carrying the investigation further.

A set of observations taken in the manner above described, and which could afterwards be reduced, would in the opinion of the writer give the best determination of the position of the point actually reached that could be made with small portable instruments, and would give in addition some information regarding the motion of the ice-sheet. Readings of the magnetic needle corresponding to those of the horizontal circle would serve to give a rough determination of the longitude of the point of observation.

THE ORBIT OF η BOÖTIS

By W. E. Harper

THIS star ($\alpha = 13^h\,49^m{\cdot}9$, $\delta = +18°\,54'$, photographic magnitude 3·8) was announced as a spectroscopic binary by Moore, in *L. O. B.*, No. 70, 1905. The thirteen measures extended over the years 1897, 1899, 1901, 1903, 1904 and 1905. Of these, four were approximate, the remaining nine definite. Since then there have been published six measures* of the same star by Küstner of the Bonn Observatory.

Work was commenced on the star here June 25, 1906, and from that time to the present forty-nine plates have been secured. Of these, thirteen were made with the Universal spectroscope as adopted for radial velocity work, twelve were made with the single-prism spectrograph and the remaining twenty-four with the three-prism instrument. Those made with the Universal spectroscope were reduced by means of the Hartmann interpolation formula, while the remaining plates were reduced from tables used here in which the micrometer settings for zero displacement of the lines are tabulated. In the case of a few of the plates made with the three-prism instrument, a remeasurement was made with the comparator, but no great difference resulted in the two methods of measurement.

Last year preliminary elements for the orbit were determined, using all the plates secured here up to March 20, 1909, and in addition the thirteen Lick and six Bonn measures. The period was found to be approximately 492 days. With this period the observations were grouped into twenty-one normal places, no group including observations of more than one period. Values of the elements were derived by the graphical method of Dr. W. F. King† and from these twenty-one observations equa-

* *A. J.*, 27, 5, 1908.

† *A. J.*, 27, 2, 1908.

tions, of the differential form of Lehmann-Filhés, were formed and a least square solution effected. The values, graphical and corrected, are given in the following table.

ELEMENTS OF ORBIT*

Elements	Graphical	Corrected
P	492· days	495·3 days
e	·25	·300
ω	300·	298°·98
K	7·8 km.	8·23 km.
γ	− 0·57 km.	− 0·60 km.
T	J. D. 2,417,730·0	J. D. 2,417,729·48
$a \sin i$		53,474,000·00 km.

It was intended, as soon as observations in all phases of the orbit had been secured with the three-prism spectrograph, to make another solution using these plates alone. They have now been secured and the following treatment is based on the results of these twenty-four plates.

MEASURES OF η BOÖTIS

Plate Number	Julian Date	Phase	Velocity	Weight	Residual
700	2417 710·75	464·43	− 0·1	4	− 2·4
764	716·68	470·36	+ 2·9	10	− 0·3
990	795·58	52·12	+ 9·0	9	+ 0·2
1294	968·84	225·38	− 3·8	10	0·
1307	970·88	227·42	− 3·5	10	+ 0·3
1332	989·94	246·48	− 5·2	10	− 0·3
1357	996·80	253·34	− 6·8	5	− 1·5
1446	8 031·91	288·45	− 7·2	7	− 0·6
1513	066·78	323·30	− 6·7	7	+ 0·7
1557	085·67	342·21	− 7·7	7	− 0·2
1553	087·67	344·21	− 7·1	9	+ 0·4
1621	115·59	372·13	− 6·0	10	+ 1·0
1663	129·61	386·15	− 7·5	9	− 1·0
1710	138·61	395·15	− 5·5	7	+ 0·5
1867	192·54	449·08	− 0·3	5	− 0·3
2115	314·97	74·37	+ 8·6	8	+ 0·2
2209	337·78	97·18	+ 5·2	7	− 1·3
2283	335 85	115·26	+ 6·0	9	+ 0·3
2396	386·71	146·12	+ 2·8	8	+ 0·7
2734	529·56	288·95	− 6·5	8	+ 0·1
2776	549·56	308·95	− 7·2	4	0·
3184	713·78	473·18	+ 5·3	5	+ 1·6
3225	727·70	487·10	+ 6·7	7	+ 0·5
3325	742·82	5·08	+ 8·0	7	− 0·1

* NOTE.—The results published in this JOURNAL, Vol. III., p. 151 were given before the work was checked. In consequence of an error, the elements in the last column of this table should be substituted for those published.

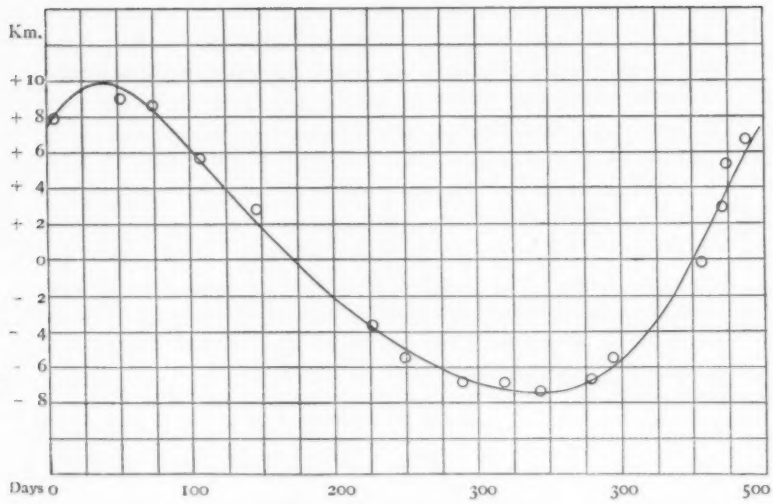
The phases are based on the period and periastron finally accepted. The weights assigned depend upon the quality of the plate and the various lines measured, the maximum assigned being 10. The star, being of solar type, gives numerous well defined lines and as a rule about 20 on each plate were measured. The residuals in the last column are scaled from the final curve.

The period of 495·3 days previously determined was increased to 497·1 as this value gave better agreement between our three-prism plates and the early definite measures. This cannot be much in error. The observations were grouped into sixteen normal places as shown in the table, the weights assigned each group being in general one-tenth of the sum of the weights of the plates comprising the group.

NORMAL PLACES

No.	Phase	Velocity	Plates in Group	Wt.	O – C	Equation – Ephemeris
1	487·10	+ 6·70	1	·7	+ ·76	– ·04
2	5·08	+ 7·90	1	·7	– ·11	– ·03
3	52·12	+ 9·00	1	·9	– ·65	+ ·04
4	74·37	+ 8·60	1	·8	+ ·22	+ ·14
5	107·35	+ 5·65	2	1·6	+ ·13	+ ·06
6	146·12	+ 2·80	1	·8	+ ·74	– ·01
7	226·40	– 3·65	2	2·0	+ ·11	·00
8	248·77	– 5·73	2	1·5	– ·77	– ·17
9	288·72	– 6·88	2	1·5	– ·29	– ·10
10	318·08	– 6·88	2	1·1	+ ·41	+ ·11
11	343·33	– 7·36	2	1·6	+ ·11	+ ·02
12	378·77	– 6·71	2	2·0	+ ·08	+ ·03
13	394·15	– 5·50	1	·7	+ ·47	+ ·03
14	455·90	– 0·21	2	1·0	– 1·07	– ·02
15	470·36	+ 2·90	1	1·0	– ·36	– ·04
16	473·18	+ 5·30	1	·5	+ 1·62	+ ·01

Preliminary values of the elements were determined in the usual graphical way and then sixteen observation equations were built up connecting the residuals with the five unknowns γ, K, e, ω and T. The solution of these gave small corrections to the preliminary values and lowered the sum of the squares of the residuals for the normal places from 6·9 to 5·2. That one solution was sufficient is seen from the small differences between the equation and ephemeris residuals given in the last column of the Normal Places.



VELOCITY CURVE OF η BOÖTIS, OTTAWA THREE-PRISM OBSERVATIONS

The accompanying table gives the graphical and final values, the latter of which may be considered as the true values of the elements of this orbit. Their probable errors are attached.

ELEMENTS OF ORBIT OF η BOÖTIS

Elements	Graphical	Final
P	497·1 days	497·1 days
e	·21	·236 ± 022
ω	322°·33	315°·20 ± 4"·84
K	8·46 km.	8·692 km. ± ·177 km.
γ	− 0·45 km.	− 0·234 km. ± ·035 km.
T	J. D. 2,418,249·45	J. D. 2,418,240·60 ± 6·0
$a \sin i$		57,735,000 km.

The probable error of a plate obtained from the last two columns of the table of measures and using the formula

$$r = \pm \cdot 6745 \sqrt{\frac{\Sigma p v v}{\Sigma p - 1}}$$ is ± 0·50 km. per second.

DOMINION OBSERVATORY,
OTTAWA, CANADA.

THE ORBIT OF Φ PERSEI

By J. B. Cannon

ϕ Persei ($\alpha = 1^h\ 37^m$; $\delta = +\ 50°\ 11'$) was announced a binary by Campbell in 1902,* as a result of measures of four plates showing a range of 36 km. per second. The spectrum is in some respects very remarkable and was grouped by Espin† with a large number of others having "remarkable" spectra, and described by him as having "F very bright." For a description of the spectrum as it appeared on the plates obtained here, nothing better can be done than to refer to an article‡ by Campbell, in which he describes spectra of several stars of this type. Speaking of φ Persei he says: "H_α is very bright, H_β fairly bright, H_γ and H_δ each of two narrow bright lines, faint, about four tenth-metres apart, H_γ brighter than H_δ." On our plates we find H_β also consists of two narrow bright lines with a dark fairly well defined centre, and although H_α does not appear on the region photographed, it might be expected from the rapid decrease in intensity of the bright lines and the increase in intensity of the dark lines as we approach the violet end of the spectrum, that H_α will consist of only one bright band. H_β gives only a very faint narrow absorption band, whereas H_δ gives, when any, faint emission lines and H_ϵ none at all. The fact of the presence of both bright and dark hydrogen lines in the spectrum places the star in Vogel's class I_c "although D_3 is not present."§ Besides the hydrogen lines, two other lines were found. *He* λ 4472 and *K*, the latter of these seeming to appear when the star was on the ascending slope of the velocity curve. Both lines, however, are very faint, and, although it is therefore

* *L. O. B.* 20.

† *A. N.* No. 2963.

‡ *Astrophysical Journal*, II., 177.

§ *Ibid.*

impossible to make any positive assertion, the imperfect measurements obtained give velocities corresponding with those of the hydrogen lines.

One hundred and twenty plates of this star were secured altogether between December 1908 and January 1910, taken with the single prism spectrographs, old and new, A striking variation in the character of the spectrum was found in the plates as the star arrived at different points in its velocity curve. The absorption bands were used entirely in the work, an attempt to obtain measures on the bright lines either directly or by means of a spectro-comparator having been found useless.

Table I. contains the lines used with their wave-lengths, and the elements to which they are due.

TABLE I.

	Wave-Length	Element
H_3	4801·527	Hydrogen
	4471·616	Helium
H_γ	4340·634	Hydrogen
H_δ	4101·890	Hydrogen
H_ε	3970·177	Hydrogen
K	3933·825	Calcium

The velocities obtained from the one hundred and twenty plates were plotted together with the velocities given by Campbell from his plates of the years 1898, 1900 and 1901 and gave a period of 126·5 days, which was assumed to be very nearly correct. The curve so obtained was found to be such as could not be satisfied by any simple elliptic motion. On the down slope the curve first dropped below zero, then rose almost to zero and again dropped to nearly 20 km. before rising again to its maximum. So far the only means employed of arriving at such a curve has been the assumption of a secondary disturbance. This is what was done in this case.

The observations were grouped into sixteen normal places, given below, together with the mean phase from final periastron, the mean weight, and residual from finally accepted elements of primary and secondary.

TABLE II.

NORMAL PLACES

No.	Mean Vel.	Mean Phase	O – C	Weight
1	+ 21·8	114·84	+ 0·01	4
2	+ 40·9	123·64	– 0·18	4
3	+ 39·7	2·72	– 2·57	5
4	+ 39·7	8·12	+ 8·53	3
5	+ 8·2	15·63	– 4·89	3
6	– 4·7	25·02	– 4·61	5
7	+ 0·9	33·96	+ 3·67	8
8	– 0·9	43·04	+ 1·12	4
9	– 4·6	53·74	– 1·30	9
10	– 10·8	65·27	– 0·43	3·5
11	– 17·1	73·68	– 0·89	2·5
12	– 15·0	83 08	+ 3·49	6
13	– 12·6	92·69	+ 0·68	4
14	– 12·3	99·19	– 6·53	5
15	+ 3·7	105·59	– 0·24	2·5
16	+ 16 5	110·29	+ 4·14	4

By means of the graphic method of Dr. King,* the elements of the orbit best suited to the curve were found. At certain

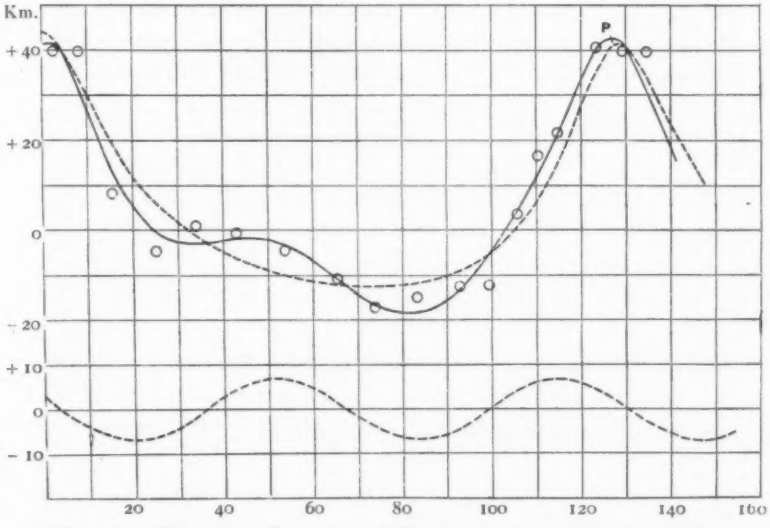


FIG. 1 — VELOCITY CURVE OF Φ PERSEI — SECONDARY CIRCULAR

Astrophysical Journal, XXVII., 125, 1908.

regions of the curve the residuals were very large. A secondary circular orbit of one half the period superposed on the primary decidedly improved matters.

The elements of primary and secondary thus found are Primary :—

$$e = \cdot 4$$
$$K = 25 \text{ km.}$$
$$\gamma = + 2 \cdot 603 \text{ km.}$$
$$\omega = 340°$$
$$T = 2{,}418{,}287 \cdot 48.$$

Secondary :—

$$K'' = 6 \text{ km.}$$
$$T'' = 2{,}418{,}330 \cdot 62.$$

(Note :— T'' is the point where the up curve crosses the zero line).

Still the residuals were far from satisfactory and it was thought that the application of Least Squares might do something towards lowering them. In the first solution all the elements of the primary, with the exception of the period, were used and K'' and T'' of the secondary. This resulted in the following corrections to the elements :—

$$\delta \gamma = + \cdot 59 \text{ km.}$$
$$\delta K = + 1 \cdot 47 \text{ km.}$$
$$\delta e = + \cdot 013$$
$$\delta \omega = + 6° \cdot 749$$
$$\delta T = + 2 \cdot 757 \text{ days}$$
$$\delta K'' = + \cdot 354 \text{ km.}$$
$$\delta T'' = - 3 \cdot 875 \text{ days.}$$

and a reduction in Σpvv from 1107 to 943. Lack of agreement between ephemeris and observation equation residuals showed the necessity for another solution. This gave the corrections :—

$$\delta \gamma = + \cdot 01 \text{ km.}$$
$$\delta K = + \cdot 43 \text{ km.}$$
$$\delta e = + \cdot 016$$

$$\delta\ \omega = +\ 0^{\circ}{\cdot}538$$
$$\delta\ T = +\ 0{\cdot}181 \text{ days}$$
$$\delta K' = +\ {\cdot}43 \text{ km.}$$
$$\delta\ T' = -\ {\cdot}168 \text{ days.}$$

and a second reduction of Σpvv from 943 to 918. The probable error of a single plate determined from residuals scaled from the curve was computed and found to be ± 6·12 km. per second. The character of the spectrum of this star hardly justifies so large a probable error. However the agreement between different plates in the same normal place indicates that the fault cannot all be laid to errors in measurement. What the reason may be it is impossible to say, but no doubt the physical condition of so early a class of stars is more or less responsible for what appear to us as irregularities. The probable errors of the elements of the primary were also determined :—

of γ ± ·737 km.
K ± 1·522 km.
e ± ·0426
ω ± 6°·195
T ± 1·957 days.

TABLE III.

SUMMARY OF CORRECTIONS

	Element	Graphic	1st Corrected	2nd Corrected
Primary :				
	γ	+ 2·603 km.	+ 3·194	+ 3·204
	K	25· km.	26·475	26·905
	e	·400	·413	·428
	ω	340°·	346°·75	347·29
	T	2,418,287·48 J.D.	2,418,290·24	2,418,290·42
	P	126·5 days	126·5	126·5
Secondary :				
	K'	6· km.	6·35 km.	6·78
	T'	2,418,330·62 J.D.	2,418,326·745	2,418,326·577
	P'	63·25 days	63·25	63·25
	pvv	1107·	943·	918·
	$a \sin i$			42,298,000·

The residuals of the normal places were now scaled from the corrected primary curve and plotted with a view to obtaining a

secondary of elliptic orbit which might give better results than those from the circular orbit. The curve was treated similarly to the primary, the primary being in the mean time considered correct. Graphically, elements were secured as before and two Least Squares corrections made with the following results.

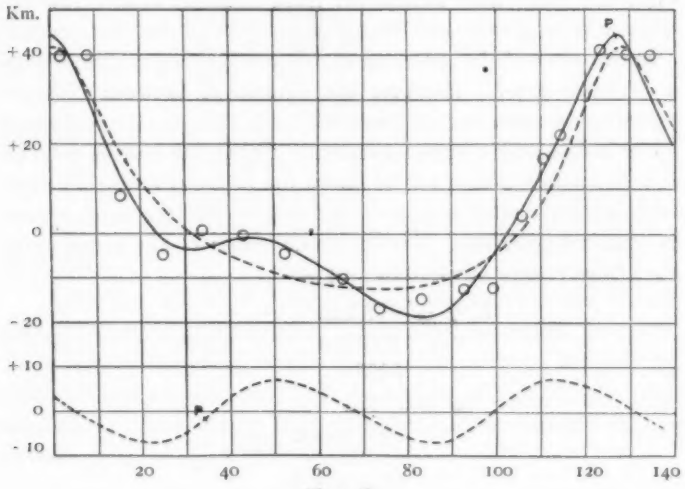


FIG. 2.

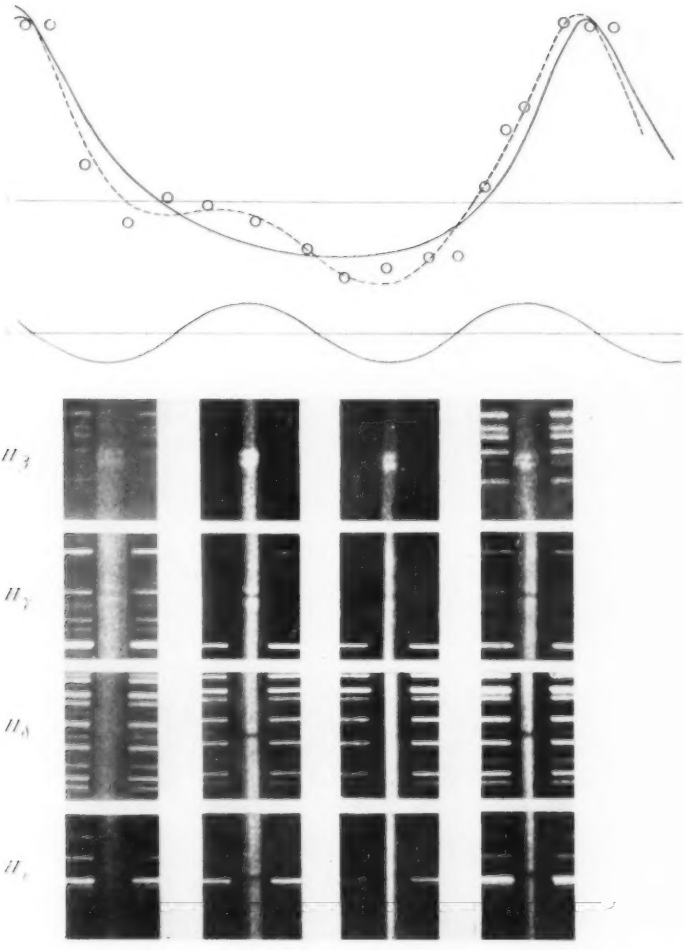
VELOCITY CURVE OF Φ PERSEI—SECONDARY ELLIPTICAL

TABLE IV.

	Element	Graphic	1st Correction	2nd Correction
Secondary :	K'	7·8 km.	6·93	6·96
	e'	·05	·145	·107
	ω'	270°·	252·255	257·145
	T'	2,418,326·42	2,418,323·48	2,418,324·37
	pvv	913	878	875

The total reduction of pvv by considering secondary elliptic is *43*. Although this reduction is small and the elements only slightly varied from the circular, yet it seems to indicate a slight advantage over the circular.

PLATE XVI.



SPECIMEN SPECTRA AT DIFFERENT POINTS OF CURVE

(Enlarged 20 diameters)

There are many difficulties which present themselves in connection with this star, and their explanation seems as yet to be far distant. The first question is:— What physical state will produce a spectrum such as this? Although Campbell, in his article already referred to, has spoken of the hydrogen lines γ and δ as being two slightly separated bright lines, the evidence of only some of our spectra can agree with this description. The strong contrast between the central band and the continuous spectrum at certain regions of the curve leaves no doubt whatever of the fact that, that separating band is due to absorption. As stated before, the absorption increases while the emission decreases as we go towards the violet. Perhaps the best suggestion offered as an explanation of this is given by Professor Frost, — quoted by Campbell.* He says:— "Measurements with the spectral photometer have shown that the *general* absorption of the sun's atmosphere is about 1·7 times as great for the violet as for the red rays; the case is doubtless similar for many of the stars, particularly for those having extensive atmospheres; if the same conditions applied to the *selective* as to the *general* absorption, at least a part of the contrast between bright H_a and dark H_γ would be accounted for."

The variation of the character of the spectrum with the star's position in the orbit was referred to early in this paper, but not gone into in any detail. There seems to be a strange coincidence in the fact that at the crest of the secondary curve the spectrum shows strong absorption while at the trough it shows very weak absorption and, if anything, slightly increased emission. Now, if a satellite about the light-giving star be responsible for this secondary disturbance — this is a mere possibility — the secondary as shown in the curve represents the effect on the primary, and the real course of the satellite's curve will be exactly opposite to that represented by the curve as shown in the figures. That is to say, when the satellite is hastening from us at its greatest speed — the trough of the curve — we have very

* *Astrophysical Journal* II., 177.

weak absorption, and when coming towards us — the crest — we have strong absorption.

Now it will be seen in the figures of the curve that the crest of the secondary, indicating greatest velocity towards us, precedes the crest of the primary, indicating greatest velocity away from us by about fourteen days. Representing this fact in a figure of an ellipse with a satellite revolving about the light-giv-

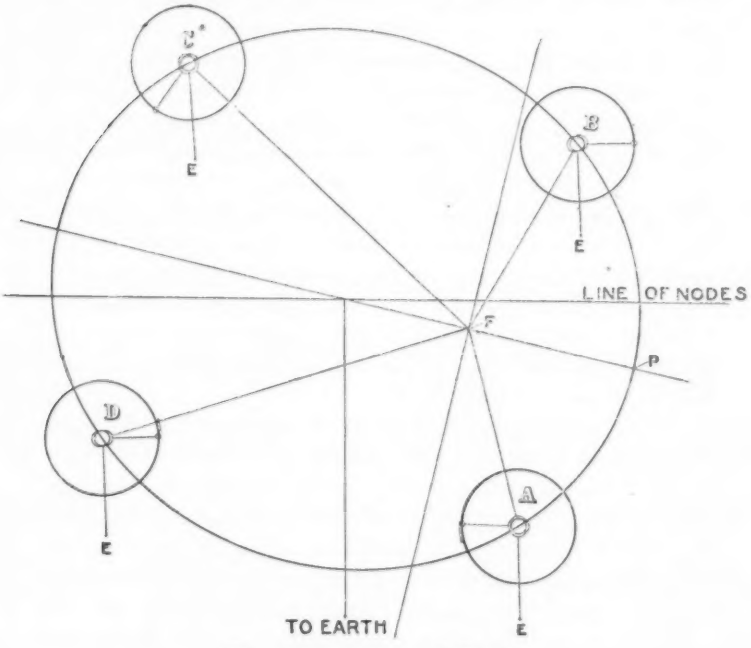


FIG. 3.—ORBIT OF Φ PERSEI

ing body as shown in figure 3, position *A*, we shall have the central dark body *F*, and the satellite almost at right angles to the light-giving body. The spectrum of the star indicates a layer of hot, dense hydrogen, producing broad, bright emission bands and outside this a comparatively rare, cool envelope of the same element giving the narrow bands of hydrogen absorption.

Judging by the width of the bands of emission and absorption, the envelope producing the former must be many times as dense as that producing the latter. Now if the tidal action be very prominent in these early stars, and it seems very probable, we may conclude that the effect will be evident almost entirely, comparatively speaking, on the outer absorbing envelope. Returning to position *A*, figure 3, applying terrestrial tidal phenomena we shall have in this position a tide on all sides of the star and a fairly heavy layer of absorbing atmosphere interposed between the emission stratum and the earth. Hence at the position we should have strong absorption.

Let us pass over positions *B* and *C* which, although they will serve our purpose, are not quite so good as *D*. At *D* we have the satellite receding at its highest speed — the trough of the curve — and the satellite and central body *F* acting almost in line. The tide in this case will result in the absorption stratum being much rarefied between the star and the earth. Hence very weak absorption.

The above is only a suggestion of a possible condition which might give some such variation as we find in the character of the spectrum of the star. Some other theory may some time be put forth which will be more satisfactory.

It is proposed at some later date,— perhaps four or five years hence,— to resume the observation of this star and make another determination of its orbit, and especially to note what changes, if any, have occurred in the secondary disturbance. It will be of interest to see if the spectrum then shows the same variation in its character as have been noted in this discussion.

In conclusion I wish to acknowledge my indebtedness to the Director, Dr. King, for his interest in the work, and to Mr. Plaskett for helpful suggestions given me during its progress.

DOMINION ASTRONOMICAL OBSERVATORY,
OTTAWA, CANADA

A LAYMAN'S DIARY OF HALLEY'S COMET, 1910

By A. F. Hunter

April 28, 1910.—At 3.50 a.m., I saw Halley's Comet for the first time with the naked eye. This was a welcome sight after two months of comet-hunting in the winter mornings. Undue expectations had been fostered by the barrelfuls of printer's ink shed by the newspapers in the cause of sensational astronomy. A clear, cold morning; the moon shining brightly; Venus as the morning star. Halley is to our left from Venus and higher up in the sky. It showed a tail of three or four degrees in length to my sight, and remained visible until about 4.20 a.m. when the dawn made it difficult to see. A week ago the comet was not visible to the naked eye, as on April 22 I looked for it without success. Since that time the sky has been cloudy every morning. Its tail spreads more widely than that of any comet I have seen, except, perhaps, that of 1882. The head of Halley's Comet is of about the 3rd magnitude. (My estimate of the length of its tail on this its first appearance agrees with the estimate made at Harvard University, as given in *Science* of May 6, 1910, viz. 4 degrees on the morning of April 27, on which day it was seen in the Eastern States, but not in this part of Canada until the following morning, owing to clouds).

April 29 and 30.—Cloudy mornings.

May 1.—Observed Halley's Comet again at 3.40 a.m. By 4·05 a.m. the dawn began to obliterate the tail. Its position was about the same as on April 28. The comet was appreciably larger than three days ago, and its tail longer. To my eyesight the tail did not expand so much as on April 28, but the increase in its length would give this impression. May 1 is said to be the date of conjunction between Venus and Halley's Comet. If so, and their distances from us about equal, then Halley's head does

not appear to have much more than half the diameter of Venus, comparing them as they appear this morning.

May 2.—At 3.55 a.m. Halley's Comet is dimly visible through the hazy atmosphere. Its tail has a length of about 6 degrees.

May 3.—Cloudy morning.

May 4.—At 3.25 a.m. the comet is quite plain. At 3.40 a.m. its tail has a visible length of about 14 degrees, having increased rapidly since the 2nd. The nucleus is increasing in size also. Its position is about the same as on April 28, when I first observed it.

May 5.—Another clear morning with the comet in full view. At 3.15 a.m. it is all quite visible, its tail extending further backward than yesterday morning. As dawn advances at 3.45 a.m. the tail shortens. The head lacks the brilliancy it had when I first saw it on April 28, but is larger. This decrease in brightness may be due to its acquiring a half-moon appearance like Venus or the moon in one of their phases, instead of the full face it had when in a more distant position from us. Its position among the stars seems to be the same as at first.

May 6.—Another clear morning and the comet in full view. Its head has still further lost its former brilliance, but appears to be larger. At 3.30 a.m. its tail extends for 30 degrees, but already toward the end of it the dawn begins to obliterate it, and at 4 a.m. it is quite faint.

May 7.—At 3.45 a.m. the comet is dimly visible through the haze. The position of its head has slightly altered to the left of its former position, this being the first time any appreciable change could be noticed.

May 8.—The atmosphere is too hazy to show the comet this morning, yet at 3.45 a.m. I thought I could see it faintly through the haze.

May 9.—At 3.15 a.m. the comet is already visible. Its tail does not seem to exceed the 30 degrees formerly reached. The

position of its head is slightly to the left, and a trifle (about half a degree) higher in the sky at 4 a.m. than formerly, but otherwise it has remained in almost the same place in the sky for nearly two weeks. The dawn begins to obliterate the tail now at 3.30 a.m. Halley's Comet now appears as large as that of 1882, but the twilight is longer, which makes it more dim than that of 1882. The tail appears broader than formerly, and the head larger, but the latter has not the sparkling brightness it had at the first.

May 10.—At 3.35 a.m. the sky is somewhat cloudy, but Halley's Comet is discernible among the stars, faintly.

May 11.—Cloudy morning.

May 12.—A clear sky at 3.30 a.m. and the comet in full view. It has moved perceptibly to the left of its former position. The tail is broader, but its length at 3.30 a.m. has been diminished by the dawn. Half an hour ago it was portentous. The head is still less in size than Venus, which has risen.

May 13 and 14.—Cloudy mornings.

May 15—A clear morning and Halley's Comet in view. At 2 a.m. the tail is well above the horizon and is traceable as a dim light something like the Zodiacal Light in February. At this hour there is no sign of the dawn. I did not get a sight of the head of the comet above the horizon, although I watched continuously for it until 3.40 a.m., but by this time the tail was quite destroyed by the advance of the dawn. At 2 a.m. and at 2.30 a.m., however, I noted the star to which the tail extended, and on the head appearing, I measured the angle made by the whole comet as 65 degrees, the star being still visible notwithstanding the dawn. While the tail shone at full length at 2 a.m. and 2.30 a.m. the last six or eight degrees at its extreme end consisted of diffused light, but it was easily discernible as part of the comet's tail. The head of the comet this morning had a nebulous appearance, and the nucleus was dim, (which was, perhaps, not altogether due to the approach of dawn), but altogether the head is

larger than before. At 2.30 a.m. there was a distinct aurora in the north, and a day or two ago I noticed a similar phenomenon at about this same hour. This morning also I noticed three "shooting stars" in the neighborhood of the comet's position about 2.30 a.m. at intervals of a few minutes apart. There is no streaking in the comet's tail except, perhaps, just at the head, the entire tail being a mere sheet of light like the Zodiacal Light or the Milky Way. My mother, who witnessed Halley's Comet this morning and also Donati's Comet in 1858, states that the tail of Donati's spread out more widely than that of Halley's this morning, and was more distinct in the darker autumn sky. The tail of Halley's this morning passed through the same point or nearly the same that it has held since April 28, but the head has extended forward and the tail further backward. It would thus appear that the earth in its course will pass through the tail. Venus had risen before I could see the comet's head this morning. My measurement of 65 degrees was made by the board-and-string method, and a divided circle, which gives a very close estimate.

May 16.—At 1.30 a.m. the tail of Halley's Comet is already coming into view. At 3 a.m. when the chief part of it has risen, it is seen to extend distinctly three or four degrees further backward than yesterday morning. Toward the end the width of the tail does not exceed three degrees, including even its diffuse edges. I did not get a sight of the head until 4.10 a.m., although it was then risen some little distance, but the haze on the horizon had obscured it. By taking two landmarks I noted the exact position of the comet's head at 4.10 a.m. Exactly an hour later the sun rose, and I measured the sun's position on rising. Allowing 15 degrees for the distance traversed by either one during the hour, I found the head of the comet to be approximately 25 degrees from the sun, by this method. Stars could be seen shining through the tail of the comet, which continues to be merely a sheet of light.

May 17.—At 2.30 a.m. the comet's tail is in view. It has about the same width toward its end as yesterday morning, or,

perhaps, is a trifle wider (nearly 5 degrees) although its edges are more diffuse and more difficult to estimate. In brightness the tail scarcely equals the Milky Way, which is nearly in the zenith and in good position for making a comparison between the two. But the tail seems to fluctuate in brightness about every five minutes, sometimes becoming more illuminated than at other times. The tail can be traced almost to the Milky Way this morning, having extended beyond its former position. From the end of the tail to a prominent star about midway along its length, I found the span to be 47 degrees, and when I sighted the head at 4.25 a.m. the span from the star to the head was approximately the same, viz., 47 degrees, making a total length for the comet this morning of 94 degrees. The head was very dim this morning, the dawn well nigh obliterating it, yet I was able to see it for a brief period. It has moved through an angle of 12 degrees since yesterday morning, according to my method of measurement by means of landmarks; the mark of yesterday morning having been permanently fixed for this purpose. This apparently indicates that it will reach the sun and that the transit will occur before the computed time of 2.52 a.m. on May 19 (Greenwich time) as announced in the newspapers. Yesterday morning (the 16th) the most intense part of the tail was distinctly in the upper or northern portion of it; but this morning (the 17th) this massing of the light to one side was not so conspicuous.

May 18.—At 2 a.m. and at 3 a.m. the sky continued cloudy, and there was no chance to see any portion of the comet, even if it had been visible. At 4 a.m., the sky having cleared somewhat, there was too much twilight to see any part of it, if still visible in the east. But in the zenith, and for short distances north and south of the zenith, the sky had a purplish tint of an unusual kind,—a faint glow or illumination in the higher parts of the atmosphere, such as one sees on rare occasions before or during a very strong display of aurora. There had been a heavy rain at 1.30 a.m. which cleared the air, and the purple color or glow was not due to cloudiness or haze, the stars being distinctly

visible through the color. Clouds again covered the sun at sunrise and all day (18th) until 5 p.m., during which period the transit may have occurred, as from 5 p.m. until sunset no dark nor even translucent object crossed the sun's disk. At about 10.30 p.m. to-day (18th) a display of aurora occurred and was visible here ; but as this is about the usual time of the day for the maximum auroral action, I do not consider it is as directly evidence of the comet's action as the colored illumination in the morning. Yet I believe the auroræ that have been common for a week past have been due to the proximity of Halley's Comet to the earth.

May 19.—There was complete absence of any glow in the zenith such as I observed yesterday morning at 4 a.m.

May 20.—Clouds in the evening obscured the western sky making any observation impossible.

May 21.—At 8.40 p.m. I obtained a sight of Halley's Comet in the western sky for the first time. Its position is about 2 degrees east of Procyon and about 25 degrees from the horizon where the sun set. As the sun is now 15 degrees beyond the horizon, (an hour having elapsed since sunset), the comet is, therefore, 40 degrees from the sun, and has travelled approximately 53 degrees since the 17th at 4.25 a.m. Making some allowance for atmospheric refraction near the horizon, such as might enter into the measurements I have made, this estimate appears to afford a second proof that the transit of the comet across the sun or near it occurred during the part of the 18th while the sun was beclouded. To-night (the 21st) the head of the comet is large but very foggy in appearance the same as on the mornings of the 16th and 17th, but the tail is not conspicuous owing to thin clouds and moonlight. There is a greater coma around the nucleus than when I first saw the comet on April 28, and the tail seems to spread out more fan-like than before it crossed the sun, but is shorter, apparently. By about 9.30 p.m. clouds obscured it.

May 22.—Cloudy evening.

May 23.—At 9 p.m. the comet is visible at times through the rifts in the clouds. It is more distinct than on the 21st, and its position better for observation, although the full moon in the east lessens the light of the tail. There is less fogginess about the head than on the 21st.

May 24.—At 9 p.m. the comet is in view but there is a hazy atmosphere, and I cannot distinguish the tail for more than 5 degrees.

May 25.—At 9.30 p.m. there is a good view of the comet with a clear sky and cool air. The tail extends for about 30 degrees distinctly and dimly for 5 degrees further. Toward its end it has a width of about 3 degrees. The head is disk-like, as it appears to-night.

May 26.—Cloudy night.

May 27.—At 9.30 p.m. the comet is in full view, but is becoming noticeably smaller, as it must naturally become, seeing the earth and itself have been receding from each other almost directly since the transit on May 18. The light of the comet continues to be of a whitish color, and has been uniformly of this color since the first appearance. To my eyesight the light of its tail fluctuates slightly in its intensity, somewhat like the streamers of aurora but much more slowly and more feebly, less perceptibly, yet enough to detect with the naked eye.

May 28.—At 9.30 p.m. the comet is visible for a short time during a break in the clouds. It is becoming still smaller, and its position among the stars is now changing only slightly. Slow changes in the intensity of the light of its tail are still apparent to me.

June 3.—Owing to lengthened twilight and decrease in size, the comet did not come into view until nearly 10 p.m. Almost a week has expired since it was last visible, cloudy nights having intervened. It is now much smaller, the tail not exceeding 20° degrees in length, and the head also minute.

Altogether, as a spectacle, Halley's Comet has been a feebler one than most people expected, but this has been chiefly owing to our long twilight at this season in northern latitudes. Nearer the equator the view, perhaps, has been better than ours. But the sensational balderdash of the daily newspapers had aroused undue expectations. And it is a pity that wild statements regarding the loss of its tail in March, the cyanogen gas, and the curvature of the tail, etc., should get credence in our reputable scientific journals like the *Scientific American* and be placed on record for the future. When it was on the other side of the sun, in March and during the early part of April, its tail may have been inappreciable to observers with telescopes, being turned directly from the sun and from ourselves. And at no time have I observed the slightest curvature in its tail, such as has been imagined by some, but not witnessed by anyone. Light passing along the full length of the tail say of 20,000,000 miles would traverse the entire course in something less than two minutes, and during that short time the distance travelled by the head of the comet would be too inappreciable to cause any curvature to be visible to the eye.

BARRIE, ONT.

WATER VAPOR ON MARS

By W. W. Campbell

THE Journal has the commendable plan of presenting all sides of a subject. However, the paragraphs headed "Water Vapor on Mars," reprinted in Volume IV., p. 157, from an unsigned *Lowell Observatory Bulletin*, are liable to give a wrong impression of Mt. Whitney weather conditions. The first two paragraphs, taken by the Lowell author from different parts of Director Abbot's article, seem to say that unusually unfavorable weather prevailed throughout the whole time that our Expedition was on the summit of Mt. Whitney. This impression is very far from the truth, and it was not Mr. Abbot's intention to convey it. My account of the Expedition (*L. O. Bulletin*, No. 169) described the weather conditions faithfully for the seven days that we were on the summit. We reached the summit on August 28th, and "light storms continued throughout the 29th and 30th." Good weather existed from August 31st to the evening of September 3rd. "The program called for observations on the nights of September 1, 2 and 3. . . . The nights of September 1 and 2 were as perfect for our purpose as could be wished, but we were prevented from completing the program on September 3 by the coming up of a storm similar to that in which we had arrived. The forenoon of the 3rd was most promising; the sky was absolutely clear; the wind was from the fair weather quarter; the humidity was low; and the sky was remarkably blue. On occulting the sun behind the roof of the shelter, one could look up to the very edge of the sun with no recognizable decrease in the blueness. I had never seen so pure a sky before. About sunset, clouds came up from the south-east and covered the sky. During the night several inches of snow fell. . . . We packed up on the forenoon of the 4th, and went home . . ."

The sling psychrometer observations, published in detail for the nights of September 1 and 2, establish that our observations on the spectrum of Mars were made with the vapor contents of

our atmosphere only a minute fraction of the vapor contents at Mt. Hamilton, Flagstaff and other observatories when similar observations of Mars' spectrum were secured, not to mention the complete elimination of the vapor-laden strata lower than Mt. Whitney (14,500 feet) and above Mt. Hamilton, Flagstaff and other observing stations.

The particular facts which should be emphasized in this connection are as follows :

I. "A spectrogram of Mars obtained at Mt. Hamilton by Dr. Albrecht on August 7, 1909, using the 36-inch refractor and 1-prism spectrograph, with the planet at altitude 40°, shows the *a* band much more strongly than does spectrogram No. 3 of the Mt. Whitney series obtained with Mars at an altitude of only 11°·2 ; and apparently about as strongly as Mr. Slipher's published spectrograms of Mars show it." The dry bulb temperature at Mt. Hamilton at the time was approximately + 20° C., the relative humidity approximately 12 per cent., and the absolute humidity approximately 2·4 grams per cubic meter ; a vapor content for Mt. Hamilton atmosphere, in the summer month of August, fairly comparable with the Flagstaff vapor contents when similar observations were made, in the winter months January and February.

II. In the spectrogram of Mars secured at Mt. Whitney, with the planet at zenith distance 40° and terrestrial atmosphere almost free from aqueous vapor, "*a* is difficult to see : if we were examining this Martian spectrum as an unknown spectrum, *we should almost certainly pass over the "a" band without suspecting its existence.*" If, as the unsigned *Lowell Observatory Bulletin* would have us believe, "the excessive moisture (on Mt. Whitney) must have pervaded the air generally," it should be seen by a blind man, even though he carry a brief for intelligent life on Mars, that the *more* moisture there was in *our own* atmosphere, the *less* there could have been in the *Martian* atmosphere, in order that the two atmospheres combined should produce the observed and almost invisible absorption effect.

LICK OBSERVATORY,
MOUNT HAMILTON,
JUNE 1, 1910.

MEETINGS OF THE SOCIETY

At Toronto

April 26.— The report of the Librarian showed the receipt of a large number of periodicals and pamphlets.

Questions asked by Mr. W. B. Musson regarding variations in the Zeeman effect, and by Mr. R. S. Muir on the variation in the position of the North Pole led to interesting discussions.

The paper for the evening was given by Mr. W. B. Musson on "Some Notes on Variable Stars." The author gave a clear concise account of the various classes of variable stars, with examples of each. He also considered the various theories put forward in explanation of these stars, and pointed out where they were incomplete. He also gave an account of the various methods of estimating the intensity of variable stars. In the discussion which followed Messrs. R. S. Muir, A. F. Miller, J. R. Collins, Dr. A. D. Watson and Professor DeLury, the president, took part. L. G.

May 10—In the Physics Building of the University.

The President, Professor DeLury, gave a lecture, open to the public, on "Halley's Comet." The lecturer gave a popular exposition of the development of the theory of comets, with special references to Halley's work.

A number of lantern slides of photographs of comets were shown, illustrating varying peculiarities of form of a number of comets. Amongst the slides exhibited were photographs of Halley's Comet taken May 4th, at the Dominion Observatory, Ottawa, and a series of photographs of Daniel's Comet showing

remarkable changes in the formation of the tail during a few hours.

May 27—The regular fortnightly meeting night occurred on the 24th, but as that day was a public holiday, the meeting was postponed until the 27th. The president occupied the chair.

Dr. Albert D. Watson contributed a paper on "Olbers, the Greatest of Amateur Astronomers." The paper sketched the life of the physician, who had spent for over fifty years, when opportunity offered, the most of every clear night in his little observatory over his home. The story of his early discovery of the minor planets and his theory concerning their origin was described. Olbers discovered the notable comet of 1819, and one of the chief method of computing cometary orbits is accredited to him. He had observed nearly all the comets reported during his lifetime.

In view of the general interest in cometary matters, the paper was considered timely and of unusual interest.

A number of recent observations and questions relating to Halley's Comet were discussed. The general consensus of opinion of the members being that the earth had passed through some of the streamers of the comet's tail on the night of May 18th as predicted, but without any ostentatious display.

J. R. C.

At Ottawa

February 24, at 8 p.m., in Y.M.C.A. Hall.—(The minutes of this meeting were inadvertently omitted from the last issue of the Journal).

Mr. J. S. Plaskett, B.A., gave a paper on "The Optics of the Telescope and the Spectroscope." In beginning Mr. Plaskett stated that as the subject was such a wide one he would necessarily treat the various portions of it briefly.

He first defined light and gave some data as to its wavelength, number of waves per second, and speed of propagation. There were two methods of treating the subject, the *real* and the

ideal, giving rise to the sciences of physical and geometrical optics. He would treat the subject from the latter point of view.

By means of experiments he showed how light in a homogeneous medium travelled in straight lines, how it was refracted when the medium was not homogeneous and the law of this refraction. The behavior of light when passed through a prism, and through lenses was shown by experiment and explained from the laws of refraction.

Next, by means of experiments and by drawings it was shown how images were formed when light passed through different lenses. In the course of these experiments the focus of a lens, the principal focus, real images and virtual images were all defined and illustrated.

Mr. Plaskett then showed how lenses were arranged to make a telescope as well as the action of the light in forming images as it passed through.

The images formed by the lenses of a telescope had defects of chromatic and spherical aberration. To remedy the first defect it was necessary to make the lens of the objective of two parts composed of different kinds of glass, while to remedy the second defect the surfaces of these two parts were required to be of a certain definite form. It was thus possible to correct for both defects.

Mr. Plaskett then spoke of the resolving power of a telescope, *i. e.* the power to distinguish between two stars very close together and a single one star. Then he told how a lens is made. It is first cut out from a block of glass by a diamond, then it is ground in a mould with emery and water, and as it approaches the proper form finer emery is used. It is finally polished by means of rouge, and tested and corrected, if necessary, for spherical aberration. As the accuracy of the surface of a good lens is within $\frac{1}{200000}$ inch, it could be well said that the production of such a lens was a work of art.

After adjournment the audience availed themselves of the opportunity of examining the lenses and other apparatus used by

Mr. Plaskett, and also of asking him questions relating to the subject.

April 3, 3 p.m., in the Observatory.—The following were elected members :—

Col. A. J. Oliver, Galt, Ontario.

Capt. F. Anderson, Dept. of Marine, Ottawa.

Mr. J. S. Chapleau, Dept. of Public Works, Ottawa.

The paper for the day was on "The Measurement of Geodetic Base-Lines with Invar Tapes and Wires," by Mr. P. A. Carson, B.A., of which the following is a synopsis.

The three essentials for measuring a base-line are (1) a standard of length, (2) a measuring unit and (3) some form of auxiliary apparatus to perform the actual measurements. The standard we have in the International metre. The measuring unit may take the form of a bar or tape. The measuring unit must be carefully standardized, and have either a permanent length or change only according to known laws. Errors in a base-line are either errors of comparsion or errors of measurement. Errors in comparison are accumulative. The greatest source of error due to measurements has always been the uncertainty in temperature. The alloy "invar" was discovered by Mr. Charles Guillaume, Asst.-Director of the International Bureau of Weights and Measures, Paris, France, some ten years ago. "Invar" is an alloy of nickel and steel, containing 36 per cent. nickel. It possesses a very small coefficient of expansion, and has been found very satisfactory as a measuring unit, not only on account of its extraordinary small thermal expansion, but also its ability to retain its standardized length. Invar, after manufacture is in a condition of molecular instability, and takes several years to reach equilibrium. Stability, however, is hastened by many mechanical and themal operations, such as étuvage, beating, rolling, etc.

The invar measuring unit, adopted by Mr. Guillaume, is a wire 24 metres long, and 1·7 mm. in diameter, mounted at its extremities with graduated scales. The wire is stretched under

a constant tension of 10 kg. by means of weights and ball-bearing pulleys. The principle of measuring is to set a series of tripods along the line, each tripod having a fixed datum mark on its top. Then by means of the wire and its graduated scales the distance between successive datum marks is measured.

The coefficient of expansion of invar ranges from $\frac{1}{30}$ to $\frac{1}{50}$ of that of steel.

The wires are standardized at the International Bureau of Weights and Measures, after being kept a year after manufacture.

For transport, the wires are rolled on a drum 50 centimetres in diameter.

The slopes between successive tripods are measured with a level and target, which fit on the tops of the tripods.

With a party organization of seven men, and using six to eight tripods, a speed of from 400 to 500 metres an hour can be attained.

In the measurement of the Kootenay Base, B.C., 8·5 kilometres in length, the line was divided into six sections. Each section was measured in one direction with one wire, and in the opposite direction with two wires. A probable error of one in 1,900,000 was obtained.

The Invar Tape Apparatus used by the U.S. Coast and Geodetic Survey and the Geodetic Survey of Canada consists of 50-metre invar *tapes* (not wires) under constant tension of 15 kg. (applied by spring balances). Successive tape lengths are marked off on copper strips on posts planted along the line. According to the report of the Coast and Geodetic Survey for 1907, six primary bases were measured with this apparatus, and a precision of 1 in 2,500,000 was obtained. The extraordinary speed of 2·5 km. per hour was attained.

Practical experience has shown that invar as a measuring unit has these advantages : Greater precision than steel, the same precision as a bar apparatus ; temperature difficulties done away with ; measurements can be made in day-time (instead of at night,

as with steel). Invar can be standardized at a Bureau of Standards instead of in the field.

Invar is also used in many instruments of precision when compensation for unequal and changing temperature is necessary, such as in pendulum rods, balance wheels of chronometers, level tubes for vials, and in graduated circles of precise theodolites.

C. E.

At Hamilton

April 22.—The chair was occupied by Mr. Wm. Bruce, 1st vice-president.

Mrs. W. G. Thompson, 3 Stanley Ave., Hamilton, was elected to membership.

The Rev. R. Atkinson, of Chesley, Ont., gave a lecture on "A Trip with a Sky-Pilot." It was illustrated with numerous lantern slides. First was shown a vast glowing nebula without form or structure, namely the Great Nebula in Orion with its mysterious "trapezium." Then the great spiral in "The Hunting Dogs" showed evidence of motion and arrangement and formation of attendant bodies. Next came the Andromeda Nebula, showing structure, which, however, was not observable until photography came to the aid of the telescope; and the spectroscope hinted that the nucleus may, perhaps, be no longer gaseous, but a plastic mass. Leading on we were shown star masses in the Milky Way and Star Clusters, such as that in Hercules, the component suns of which are calculated to be 4,000 millions of miles from one another, yet the whole appearing as a spot to us.

The Pleiades showing remains of nebulosity, and the double cluster of Perseus quite free therefrom, formed the next step, and so on till we reached a solar system such as ours.

The lecturer led us from planet to planet up to the sun itself speaking of its sports, its prominences, the corona and the zodiacal light. In conclusion the lecturer gave a number of views of the moon, which he termed a "cinder of a world."

A hearty vote of thanks was tendered the lecturer, on motion of Mr. J. H. Smith, seconded by Rev. J. J. Morton.

May 27.—The local president, Mr. G. Parry Jenkins was in the chair.

Robert S. Wallace, 198 Herkimer St., Hamilton, was elected a member.

Rev. Canon Howitt delivered an illustrated lecture entitled "Astronomy and the Bible."

Genesis i. 14, declares that the stars were to be for signs, and the question arises, signs of what? The statement in answer is that all the doctrines of the Christian Faith were foreshadowed in the constellations, especially those of the Zodiac. For centuries the reading of these signs was left to the astrologers who tried to force them to declare concerning the details of individual lives, but now the reading of the signs shows that before the revelation by word of mouth there was a witness in the heavens.

Psalms xix. claims "The heavens declare the glory of God," and Paul in Romans x. 16-18, speaks of "witness unto the ends of the world."

Referring to the signs of the Zodiac, their universality was spoken of being pictured in the temples of Baal Bek, Denderah, Esneh, also on ruins in India, Persia and even in Mexico, the explanation being that they were named by God as claimed in the Book of Job, 147th Psalm, and Isaiah xl. 26.

The lecturer then pointed out that the signs of the Zodiac were upon a circle, and the question arose where rightly to begin.

Referring to the Great Pyramid and the Sphinx, he called the first a great astronomical observatory and the latter a great astronomical sign, for being formed of a woman's head and lion's body it showed that Virgo was the place to commence and Leo the place of ending. Taking up then the various signs separately, each was explained in its significance.

Virgo, the Virgin bearing the "branch."

Coma, the desired.

Centaurus, the dual nature.

Boötes, the coming one.

Libra, a price to be paid.

Crux, the price.

Lupus, the victim slain.

Corona, the reward.

Those desirous to follow up the subject were referred to Dr. Brillings work, "The Witness of the Stars."

At the close, two views of Halley's Comet taken at Ottawa Observatory, by Mr. Plaskett on April 3 and 5, were thrown upon the screen.

T. H. W.

NOTES FROM THE DOMINION OBSERVATORY

MERIDIAN WORK

In the last issue of this JOURNAL* were given the relative personal equations of the five observers who took part in the longitude operations of 1908; the observations were all made with three-inch Cooke transits equipped with registering transit micrometers. In the longitude season of 1909 the same instruments were used and the same observers engaged. As several of the longitude stations were in the west, and were determined from Winnipeg as base station, the regular longitude observations at Ottawa were more limited than in previous years, extending over only two months (June 7–August 10). As in the preceding year, these observations were made use of to determine the relative personal equations of the three observers engaged, by depending on the constancy of the clock rate from day to day. The results are as follows, adopting *C S* † as the standard observer—

S	·097 sec.	± ·011
N	−·007 "	± ·010
C S	·000	

During the period Oct. 20 – Dec. 4 a special series of observations was made, in which all five observers took part, either two or three observers working simultaneously on each night. If *A* denote the most probable value of clock-correction according to *C S* at any given epoch, and *a*, *b*, *c*, *d* the personal equations of the other observers relative to *C S*, the most probable values of the clock-corrections obtained by them would be respectively *A* − *a*, *A* − *b*, etc. Hence we obtain as many observation equations as there were separate determina-

* p. 96.

† Home observers :—R. M. Stewart — *S*; D. B. Nugent — *N*; C. C. Smith — *C S*; field observers : F. A. McDiarmid — *M*; W. C. Jaques — *J*.

tions of clock-correction, the unknowns being the quantities a, b, c and d, together with the same number $A's$ as there were different epochs of observation. In this way the personal equations were determined independently of clock-rate; the number of oberservation equations was 46, the number of unknown 22. The values obtained are as follows :—

S	·080 sec. ± ·010
N	·001 sec. ± ·009
$C\,S$	·000 sec.
M	·063 sec. ± ·010
J	·075 sec. ± ·009

The values for the home observers agree with those obtained from the previous series within the limits of the probable errors. By combining the two series of observations with appropriate weights* the following definitive values of personal equation were obtained ; for comparison, the corresponding values for 1908 are subjoined.

	1909	1908
S	·080 sec. ± ·007	·034 sec.
N	− ·014 sec. ± ·006	− ·014 sec.
$C\,S$	·000 sec.	·000 sec.
M	·060 sec. ± ·009	·025 sec.
J	·070 sec. ± ·008	·061 sec.

It will be noticed that the relative personal equations of N, $C\,S$ and J have remained practically unchanged, while those of S and M, though relatively to one another practically unchanged, have changed relatively to the remaining three observers.

In the series of observation equations for the period October 20 – December 4 the "probable error of a single observation" derived from the residuals is evidently nothing else than the probable error of a single observed clock-correction ; its value is ·0173 sec. An independent determination of the same quantity was obtained from the average discordance of two sets observed on the same night ; in the two series of observations there were

* This was done, not by combining the results, but by the more accurate method of forming a single set of normal equations from all the observations.

33 such nights, for which the average discordance was ·0314 sec.; the probable error of a single set derived in this way is ·0187 sec.

NOTE.—The following errata occur in the article "Personality with the Transit Micrometer" in the March–April number of this JOURNAL.

P. 96, line 30. For "– ·14 sec." read "– ·014 sec.

P. 98, line 12. Omit "not."

P. 98, line 19. For "inexplicable" read "explicable."

P. 103, last line of table. For "– ·0128 (m–4)" read "– ·0129 (m–4)." R. M. S.

COMET NOTES

Cloudy weather prevented the observing of Halley's Comet in the eastern sky until April 12. The next clear morning was April 21 and then April 27, when the comet was first seen here with the unaided eye. Photographs have been taken on every possible occasion, the accompanying table giving the time and duration of exposure, where the plates were strong enough for reproduction.

TABLE OF EXPOSURES

Plate	Date	Exposure		Camera*	Remarks
		Beginning	Duration		
	1910	h m	h m		
1	May 3	20 00	0 37	*O.*	Cloudy for 10 minutes
2	May 5	19 48	0 36	*O.*	
3	May 9	20 2	0 20	*O.*	Floating clouds
4	May 27	15 23	0 44	*O.*	Floating clouds for 10 minutes
5	May 27	15 23	0 44	*N.*	
6	May 28	14 10	1 00	*O.*	Clear
7	May 28	14 10	1 00	*N.*	
8	June 3	14 30	1 32	*O.*	Hazy towards end of exposure.
9	June 3	14 30	1 32	*N.*	
10	June 4	14 32	1 28	*O.*	
11	June 4	14 32	1 28	*N.*	
12	June 8	14 38	1 17	*O.*	
13	June 8	14 38	1 17	*N.*	
14	June 9	14 35	1 16	*O.*	Hazy the last 30 minutes
15	June 9	14 35	1 16	*N.*	

* *O* refers to the 8-inch Brashear Doublet which gives a field of about 11° on an 8 x 10 plate.

N refers to a new Zeiss lens which gives a field of about 40° on an 8 x 10 plate. This lens has a speed of *f* 3·5 and is mounted on the objective end of the 15-inch Equatorial so that the dome may not cut off any light.

Following are the observation notes :

April 27—First view with naked eye : about 1° of tail visible.

April 30—Magnitude about 3 ; nucleus very star-like ; 3° of tail visible.

May 3—Length of tail 7° ; see plate ; magnitude about 2·5.

May 5—Magnitude of comet about same : length of tail 10° ; nucleus eccentric ; outline of coma parabolic ; see plate.

May 9—Length of tail 20° ; see plate.

May 14—Length of tail 40° ; clouds prevented photographing.

May 15—Length of tail over 15° ; tail visible at 1.30 a.m., head visible at 3.30 a.m.

May 21—First glimpse of comet after transit ; length of tail about 12°.

May 22—Nucleus brighter than on May 21.

May 26—Had a glimpse of comet through broken clouds ; length of tail about 40°.

Exposures were made on May 27 and 28 and June 3, 4, 8 and 9, as given in the accompanying table.

The Seismograph—Bosch Photographic, 200 Grammes

The following earthquakes have been recorded since the last notes were sent :—

1910		N–S Component	E–W Component
March 30		h m s	h m s
	1st P. T. (?)	. . .	17 01 38 G.M.T.
	2nd P. T. (?)	17 18 06	17 16 25
	P.P.	17 26	17 26
	Max.	18 00	18 00
	End	19·5	19·5
April 12			
	1st P. T. (?)	0 35 20	0 35 42
	2nd P. T.	0 46 44	0 46 45
	Max.	0 46 50	0 46 50
	P. P. (?)	0 50 15	0 51
	End	1 45	2 00

		N–S Component h m s	E–W Component h m s
April 13			
	Waves	6 53	6 50 48
	Long Waves	7 01 32	7 02
	End	7 35	7 38
April 27			
	2nd P. T. (?)	1 36 13	1 38 49
	Long Waves	1 51	1 47
	End	2 0	2 10
May 1			
	Waves	. . .	19 01
	Long Waves	19 31·5	19 32
	End	20·0	20 25
May 5			
	1st P. T. (?)	0 34 50	. . .
	2nd P. T. (?)	0 40 22	0 40 35
	P. P.	0 45	0 45·5
	Max.	0 51	0 49
	End	1 10	1 20
May 11			
	1st P. T.	7 31 39	. . .
	2nd P. T.	. . .	7 36·5
	P. P.	7 40	7 40
	End	7 50	8 03
	Distance to epicentre 3000 km.		
May 12			
	1st P. T.	9 11 03	9 11 02
	2nd P. T.	. . .	9 15 06
	Waves	. . .	9 18 40
	Max.	. . .	9 28
	End	9 31	9 45
	Distance to epicentre 2500 km.		
May 13			
	1st P. T.	8 07 29	8 07 20
	2nd P. T.	8 14 39	8 14 36
	P. P.	8 21 50	8 21 16
	Max.	8 32	8 32
	End	9 54	10 27
	Distance to epicentre 5600 km.		

		N–S Component h m s	E–W Component h m s
May 15			
	1st P. T. (?)	16 04 20	16 04 36
	Long Waves (?)	. . .	16 07
	End	16 15	16 20
May 20			
	1st P. T.	12 12 45	12 12 18
	2nd P. T.	. . .	12 17 10
	P. P.	12 20 20	12 20 20
	Max.	. . .	12 26·5
	End	12 40	12 55
	Distance to epicentre 3200 km.		
May 22			
	1st P. T.	6 36 28	6 36 28
	2nd P. T.	6 47 14	6 47 13
	P. P.	6 56	6 57
	End	7 35	8 00
	Distance to epicentre 9600 km.		
May 31			
	1st P. T.	5 02 22	5 02 22
	2nd P. T.	5 08 08	5 08 00
	P. P.	5 15 20	5 15 24
	End	5 40	6 20
	Distance to epicentre 4000 km.		
June 1			
	Waves	. . .	6 21 37
	Long Waves	. . .	6 33·5
	Long Waves	. . .	6 55·5
	Long Waves	. . .	7 52
	End	. . .	8 15

MAGNETIC OBSERVATIONS

Magnetic observations for variation of declination during the transit of Halley's Comet in the evening of May 18 were made with magnetometers at Ottawa and at Grassett on the Canadian Pacific Railway, north of the east end of Lake Superior.

At Ottawa at 9.30 p.m. and 11.45 p.m, Eastern Standard Time, a deflection of 14′ from the average declination was noted ;

the observations extending from 6 p.m. to the following 1 a.m. At Grassett the observations began at 1.25 a.m., Eastern Standard Time, of May 18, and continued at intervals of five minutes and less to the following midnight. The maximum declination was at 11 a.m., 4°17′·1 and the minimum a little over 12 hours later at 11.50 p.m., 3°30′·9, a difference of 46′; while from 10.20 p.m. to 10.26 p.m. a deflection of 42′ was observed, from 3°29′·9 to 4°12′·3.

At Ottawa it was rainy, At Grassett it was showery, but occasionally there was a rift in the clouds showing the presence of the aurora borealis.

It will be observed that the magnetic disturbances were small, such as quite frequently occur, and hence disappointing as far as the effect of the transit of Halley's Comet is concerned.

OTTO KLOTZ.

DOMINION OBSERVATORY,
OTTAWA, CANADA,
June 2, 1910.

NOTES FROM THE METEOROLOGICAL SERVICE

MAGNETIC OBSERVATIONS

During months of April and May no disturbances of great magnitude occurred.

The 1st, 3rd 12th, 23rd, 28th, 29th and 30th of April were lightly disturbed with undulatory movements each side of the normal curve. On 18th and 27th there was medium disturbance of short duration.

During May the 2nd, 3rd, 4th, 13th, 14th, 15th, 16th, 18th, 26th, 27th and 28th undulatory movements with no great departure from normal curve. On 24th and 25th the movements were serrated.

R. F. S.

Month	Mean of Month	Max.	Date	Min.	Date	Monthly Range	Amplitudes--Mean Daily	
							From hourly readings	From Means of Extremes
	Declination							
	° ′ N W	° ′		° ′		° ′	′	′
April	6 03·0	6 48·8	18	5 31·6	27	1 17·2	10·8	22·0
May	6 03·1	6 21·6	18	5 35·6	24	0 46·0	9·2	17·5
	Bifilar							
April	·162667	·163192	28	·158847	27	·004345	·000451	·000982
May	·162750	·163643	25	·161593	24	·002050	·000409	·000692

SUMMARY REPORT OF THE WEATHER IN CANADA

APRIL, 1910

Temperature—The temperature was below the average over Vancouver Island and along the coast line of British Columbia,

but in all the other portions of the Dominion, it was above the average, and usually to a marked extent. The positive departures for the most part ranged between 4 and 5 degrees, except in Alberta and Saskatchewan, where they were more pronounced; from 9 to 13 degrees being recorded in the southern portions of those Provinces. The negative departures in Western British Columbia varied between 1 and 4 degrees.

Precipitation—The precipitation was below the average quantity in many localities in British Columbia; very light in Alberta and Northern Saskatchewan, in most places less than half the average amount, but rather above the normal in Southern Saskatchewan and over Manitoba; less than the average in the Lake Superior District, and locally in a few other portions of Ontario; and above the average elsewhere in the Dominion. In the environs of Lake Ontario, including some little distance to the northward, also northwestward to the Georgian Bay, the rainfall was very heavy. Orangeville recorded 6 inches, Toronto 5·1 inches. and Grantham 5·8 inches. Lambton, Kent and Essex Counties also had much rain, Cottam receiving 4·9 inches. In Quebec the positive departure varied from half an inch in the western portion to a larger quantity in the Gaspé Peninsula; and in the Maritime Provinces from one half to nearly five inches, the excessive departures occurring in New Brunswick and Western Nova Scotia. There was very little snow recorded during the month, the most noticeable fall being that which was experienced between the 15th and 17th, in a portion of Manitoba.

May, 1910

Temperature—The mean temperature of the month was below normal in Eastern Saskatchewan, Manitoba, Ontario and Western Quebec, and above normal in British Columbia, Alberta, Western Saskatchewan, Eastern Quebec and the Maritime Provinces. The widest negative departures occurred in Southwestern Ontario and in Manitoba, where the differences from average were respectively 4° and 3°, while the largest positive departures

Temperatures for April and May

Station	April		May	
	Highest	Lowest	Highest	Lowest
Yukon				
Dawson	52	-12	74	22
British Columbia				
Atlin	51	5	66	24
Agassiz	85	30		
Barkerville	65	10	74	24
Kamloops	92	28	94	36
New Westminster	77	32	76	36
Port Simpson	58	27	60	34
Vancouver	75	33	76	36
Victoria	69	32	74	39
Western Provinces				
Battleford	88	18	79	18
Calgary	84	30	80	18
Carman			75	10
Edmonton	83	13	81	14
Medicine Hat	96	24	84	23
Minnedosa	78	11	81	15
Moose Jaw	92	15	86	13
Oak Bank	72	14	89	20
Portage la Prairie	80	15	85	19
Prince Albert	86	16	79	20
Qu'Appelle	89	13	81	15
Regina	89	13	84	12
Swift Current	89	20	81	14
Winnipeg	75	15	85	19
Ontario				
Agincourt	73	25	78	30
Aurora	75	21	76	25
Bancroft	75	17	77	24
Barrie				
Beatrice	74	22	71	25
Birnam	77	21	74	28
Bloomfield	73	26	73	34
Brantford	79	25	80	30
Bruce Mines	62	25	72	27
Chatham	76	24		
Clinton	77	22	75	25
Cottam	78	21	80	25
Cockburn Island				
East Toronto	77	25	81	30
Gravenhurst	75	23	75	21
Guelph	77	25		
Haliburton	76	20	77	22
Hamilton	74	28	80	35
Huntsville				
Kenora	70	8		
Kinmount	69	19	74	22
Kingston	70	25	74	40
Lakefield	65	27	70	25
London	79	23	79	27
Lucknow	73	20	72	23
Madoc	73	24	75	29
Meaford	79	28	72	32
Midland	70	28	75	35
North Gower	78	23	80	10
Otonabee	66	26	76	34
Ottawa	73	25	76	35
Owen Sound	80	25	75	26
Paris	80	23	80	30
Parry Sound	77	23	76	29
Peterboro'	74	28	75	31
Point Clark	72	24		
Port Arthur	68	17	73	23
Port Burwell	70	22	70	32
Port Dover	68	24	71	30
Port Hope				
Port Stanley	65	21	68	28
Ronville	72	21	74	24
Sarnia	75	25		
Southampton	79	24	76	28
Stonecliffe	77	20	81	25
Stony Creek	74	24	78	33
Stratford	75	25	78	26
Toronto	74	27	80	32
Uxbridge	73	19	73	29
Wallaceburg	76	24	79	30
Welland	79	25		
White River	66	12	74	14
Quebec				
Brome	77	19	77	25
Father Point	62	20	75	26
Montreal	71	27	76	36
Quebec	64	20	75	28
Sherbrooke	77	23	78	27
Maritime Provinces				
Charlottetown	64	23	71	33
Chatham	72	20	79	30
Dalhousie	63	15	70	21
Fredericton	72	20		
Halifax	68	24	70	31
Moncton	73	19	76	29
St. John	66	26	70	29
St. Stephen	70	20	72	28
Summerside				
Sussex	71	21	71	23
Sydney	69	22	78	29
Yarmouth	65	23	70	31

from 2° to 4°, occurred in British Columbia and in Eastern Quebec.

Precipitation--Over the larger part of the Dominion the rainfall was something less than average, but in the Province of Quebec and in parts of Southwestern Ontario and Southern Saskatchewan the average was exceeded by a small quantity. The largest deficiency occurred in the southern portions of Alberta and in the Ottawa Valley, but nowhere were departures from the normal sufficient to lead to injurious results.

Earthquake Records by Milne's Seismograph

TORONTO

R. F. Stupart, Director.

P.T. = Preliminary Tremors. L.W. = Large Waves. Time is Greenwich Civil Mean Time, 0 or 24 h = midnight.

No.	Date 1910	P.T Comm	L.W. Comm.	Max.	End.	Max. Amp.	Durat.	Remarks
		h m	h m	h m	h m	mm.	h m	
906	Apr. 12	0 41·0	.	1 4·2	2 5.8	0·90	1 24·8	Costa Rica
907	" 13	6 58·0	7 2·0	7 3·0	7 9·0	1·00	0 11·0	
908	" 15	4 6·8?			4 11·0?	0·10	0 4·2	Doubtful as to being seismic
909	" 18	7 50·8			7 55·5	0·10	0 4·7	
910	" 27	1 38·5			2 0·8	0·40	0 22·3	
911	May 1	18 53·0			20 29·0	0·20	1 36·0	
912	" 5	0 42·8		0 46·5	1 19·0	1·00	0 36·2	Costa Rica
913	" 11	7 40·0			7 54·0	0·05	0 14·0	
914	" 13	8 15·3	8 25·4	8 33·5	10 28·0	7·20	2 12·7	
915	" 20	12 16·6	12 24·9	12 25·8	13 4·2	4·20	0 47·6	
916	" 22	6 39·8		7 22·0	7 50·0	0·40	1 10·2	
917	" 27	23 34·5			23 40·2	0·15	0 5·7	
918	" 31	5 2·3		5 19·3	6 52·2	1·30	1 49·9	

Vib. 14·8 seconds. 1 mm. = 0″·64

VICTORIA, B. C.

E. B. Reed. Superintendent.

No.	Date 19 9	P.T. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Durat.	Remarks
		h m	h m	h m	h m	mm.	h m	
935	Apr. 11	19 4·4			19 8·4	0·05	0 0·0	
936	" 12	0 35·0	0 45·2	0 45·7	1 40·0?	2·10	1 5·0	
937	" 12	22 39 0?		23 14·0	24 45·0	0·80	2 7·0	
938	" 13	6 38·0			7 45·0	0·05	1 7·0	
939	" 15	2 18·5?			6 00·0	0·25	3 41·5	[seismic
940	" 18	?7 44·0			7 56·0?	0·20	0 12·0	Doubtful as to being
941	" 27	?1 42·0			1 48·5	0·15	0 6·5	Doubtful as to being
942	" 27	1 55·0		2 4·0	2 25·2	0·50	0 30·2	[seismic
943	May 1	18 55·0			20 35·0	0·25	0 40·0	
944	" 5	0 57·1			1 17·0	9·20	0 19·9	
945	" 11	8 0·3			8 4·0	0·10	0 3·7	
946	" 13	8 3·2	P_2 8 6·9 P_3 8 9·6 L_w 8 11·8	8 15·5	10 30·5	8·00	2 27·3	Fairly large. Costa [Rica
947	" 20	12 20·7			12 23·5	0·05	0 2·8	
948	" 20	12 32·9			12 49·7	0·20	1 16·8	
949	" 22	6 33·7			7 50·5	0·20	1 16·8	
950	" 31	5 2·3	5 15·1	5 19·6	6 43·8	12·30	1 41·5	

Vib. 15 seconds. Angular val. 1 mm. = 0″·76.

J. Y.

ASTRONOMICAL NOTES

On September 30, 1909, when the region of the Syrtis Major came round again into view after its periodic hiding of six weeks, due to the unequal rotation periods of the earth and Mars, two striking canals were at once evident to the east of the Syrtis in places were no canals had ever previously been seen. Not only was their appearance unprecedented, but the canals themselves were the most conspicuous ones on that part of the disk. They ran one from the bottom of the Syrtis (lat. 20° N., long. 285°), the other from a point part way up its eastern side (lat. 17° N., long. 284°), and, curving slightly to the left as they proceeded south, converged to an oasis, itself new, on the Cocytus (lat. 5° N., long. 265°), about two-thirds of the distance to where that canal meets the Amenthes. The Amenthes itself was not visible except possibly as a suspicion. With the two main canals were associated several smaller ones and at least two oases, all previously unseen, while from their interconnection they all clearly made part of one and the same addition to the general canal system.

Many independent drawings of the phenomena were made both by the Director and by his assistant, Mr. E. C. Slipher, and in the course of the next few days the new canals were photographed, appearing on the plates as the most salient canals in their part of the planet.

The record books were then examined, when it appeared that not a trace of them was to be found in the drawings of August, July, June, or May, when this part of the planet was

depicted. That they had not been observed in previous years was then conclusively ascertained by examination of the records of those years. The record of canals seen here is registered after each opposition in a fresh map of the planet's surface. This has been done since the beginning of the critical study of Mars at this observatory in 1894. Now when these maps came to be scrutinized for the canals, each of them showed blank of any such features. Nor had any observer previous to 1894 recorded them, as the observatory library of the subject bore witness. Schiaparelli had never seen them nor had his predecessors or successors. This determined definitely that no human eye had ever looked upon them before. But stirring as it is to know that one is the first to see a new geographic feature on another planet,—akin to the thrill of finding unknown land in our own antarctic regions, —a much deeper scientific interest attaches to the question whether a phenomenon previously undiscovered was also previously non-existent; for in that case one has seen something come into being with all that such origination implies.—PERCIVAL LOWELL in *Lowell Observatory Bulletin*, No. 45.

UPON WHAT THE RADIATION AND ABSORPTION OF AN OBJECT DEPENDS.—The amount of energy emitted by incandescence per second per unit area (smooth) of an object depends upon its composition, its temperature, and the refractive index of the surrounding medium, and not in any way upon the temperatures, compositions, or positions of neighboring objects; while the energy absorbed depends upon the composition of the absorbing surface and also upon the amount and quality of the incident energy, that is, upon the compositions, temperatures, and angular sizes, as viewed from the absorber, of surrounding objects.

As surfaces are ordinarily measured it is necessary to consider their physical state. A mat surface radiates and absorbs more than does a smooth one, because of multiple reflections within the minute cavities and its consequent approach to a full radiator, or ideally black body.—W. J. HUMPHREYS, *Astrophysical Journal*, Vol. XXI., No. 4.

A TRACT has been received from West China embodying certain reassuring facts contained in the paper on "Halley's Comet" by Dr. A. D. Watson, published in the May-June issue of this JOURNAL for 1909. Parts of this article were translated substantially into Chinese and circulated widely to allay the fears of certain classes of the people who were being influenced by superstitious or designing persons. The tract is thought to have helped to allay the apprehensions of disaster which were expected to take place upon the comet's reappearance.

J. R. C.

HALLEY'S COMET

Spectral, mysterious, flame-like thing
Cleaving the western night,
Chrysalis waking from dreams to fling
Out of thy spirit's long chastening
Far-flashing streams of light.

Tell us thy thought of the things that are:
How doth the morning sing?
What hast thou seen in the worlds afar?
Tell us thy dream, O thou silvery star,
Bird with the white-flame wing.

What though the glow of thy fading ray
Dim and elusive seem,
Constant thou art to the sun's bright sway,
Faithful and true in thy tireless way,
True in thy spectral gleam.

Rising anew from thine ancient pyre,
Vapor and dust thy frame,
Still art thou Psyche, the soul's desire,
Wingless save when in reefs of fire
Mounting in shaft of flame.

TORONTO. A. D. WATSON

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries.

WATER VAPOR AND OXYGEN ON MARS

In the issue of the JOURNAL for November-December of last year there was a review of the evidence regarding the presence of water vapor and oxygen on Mars, and the conclusion reached was that we have no certain positive evidence of the existence of these substances there.

In the last number, under "Astronomical Notes," quotations were given of statements made by Director C. G. Abbot and Professor Lowell regarding the weather conditions during the notable visit of the expedition from the Lick Observatory to Mount Whitney last August for the purpose of observing the spectra of Mars and the moon under identical and favorable conditions.

In the present number (page 212) Director Campbell discusses the atmospheric conditions during the time of the expedition. The evidence is certainly very strong that if there is any water vapor in the planet's atmosphere its amount is extremely small compared to that in our own atmosphere.

A still more recent investigation into the question has been made by Director Campbell and Professor Albrecht, an account of which is contained in the *Publications* of the Astronomical Society of the Pacific, No. 131, April 1910. As is well-known, the spectroscope enables us to measure the velocities of light-giving bodies in the line of sight. On the other hand, if we know the rate of motion of such a body relatively to the earth, we can determine which lines in its spectrum are due to light from the body and which are due to absorption by our own

atmosphere, simply by measuring the relative displacements of the lines.

In order to apply this method to Mars a suitable grating spectrograph was constructed and attached to the 36-inch refractor, and the spectrum of the planet was photographed during January and February of the present year, at which time Mars was receding from us at a rate of about 19 kilometres per second. If the absorptions by water vapor in the atmospheres of Mars and our earth were equal, the water vapor lines in the spectrum would have appeared of double-width. But the terrestrial lines were not increased in width; indeed, no trace whatever of the companion lines from Mars could be found.

Thus the conclusion is further strengthened that if there is any water-vapor or oxygen on Mars its amount is small in comparison with that on the earth.

In order, if possible, to terminate the disagreement amongst very competent observers regarding the "geometrical" markings on Mars, Venus and Mercury, Professor R. G. Aitken, of the Lick Observatory, has made the suggestion that Professor Lowell invite Professor Barnard of the Yerkes Observatory, Professor W. H. Pickering of Harvard and M. Antoniadi of l'Observatoire de Juvisy, — all expert students of planetary detail, — to join him at his observatory during the next oppasition of Mars, and thus allow observations to be made by all with the same instrument under identical conditions.

The date given under the little sketch of Halley's Comet in the last issue (page 158) was wrong. It should have been "4 a.m. April 28, 1910."

THE TRANSIT OF HALLEY'S COMET ACROSS THE SUN AND THE PASSAGE OF THE EARTH THROUGH THE COMET'S TAIL

Probably the most interesting features in connection of the present apparition of Halley's Comet were the comet's transit

over the sun's disc and the earth's passage through its tail. Information has come in from various points distributed over the earth's surface, and while nothing was seen of the transit of the head there is evidence of our passage through the tail.

For the time of transit Kobold gave : ingress, May 18^d 15^h 17^m ; egress, May 18^d 16^h 17^m, Greenwich Mean Time. According to Leuschner the conjunction in R. A. took place at May 18^d 16^h 7^m (G.M.T.) or May 18, 11.07 p.m. Eastern Standard Time. At that time the comet was 3′ 0″ N. of the sun's centre. (Attention may be drawn to the computations made by Mr. A. F. Hunter in his admirable record of observations in this issue (page 204). According to his simple measurements the transit occurred earlier on the 18th. I think the discrepancy will be found in Mr. Hunter's somewhat rough approximations).

According to the above calculations the transit was to be visible in Asia, Australia, also over a portion of the Pacific Ocean and a part of Europe.

In the *Astronomische Nachrichten* No. 4414 are given reports from various stations.

Hartwig of Bamberg (Lat. 49° 51′ N., Long. 0^h 44^m E.), reports no trace of the transit of the comet's head, and nothing of the tail unless a streak through α Pegasi at about 14.15 Bamberg M. T. Strömgren of Copenhagen reports that nothing of the comet was perceived during the entire night (May 18-19), and no trace of the transit, though watched for by two observers.

Wolf of Konigstuhl, Heidelberg, made careful observations, but saw nothing of the comet in transit. He reports, however, peculiar atmospheric phenomena on May 19. Late in the afternoon was seen a Bishop's Ring about the sun, and the twilight phenomena were brilliant, comparable to those succeeding the eruptions of Krakatoa and Mont Pelée. About the moon was an exceptionally intense Bishop's Ring, having an outer radius of 28°.

At Upsala (Lat. 59° 51′ N., Long. 1^h 11^m E.) the sun was observed from 15^h to 17^h G. M. T., May 18, with a polarisation

helioscope on a 36-cm. refractor. The sky was cloudless and the atmosphere good, but nothing of the comet was seen.

W. Krebs at Grossflottbek observed on the morning of May 19 an aureole about the sun of radius 5°, and also a mock sun.

At Cracow, (Lat. 50° 4′ N., Long. 1^h 20^m E.), Rudzki reports a magnetic storm during the passage of the earth through the comet's tail. The sky was cloudy. There was a minimum between 14^h 0^m and 14^h 15^m and a maximum between 16^h 30^m and 16^h 45^m G. M. T.

Franz of Breslau, (Lat. 51° 7′ N., Long. 1^h 8^m E.) reports that on May 19 at 11.15 G. M. T., two observers saw two bright acrs in the northern sky. They arose united from a point about midway between α Aurigæ and α Persei, though the point of junction shifted its position towards α Persei. According to the observers the phenomenon could not have been due to clouds nor to the aurora.

At Kiel nothing extraordinary was observed, and at Athens the passage of the head of the comet manifested no sensible phenomena.

Mr. Ferdinand Ellerman (of the Mt. Wilson Solar Observatory) was in charge of the expedition organised by the Astronomical and Astrophysical Society of America to observe the comet in the Hawaiian Islands. A set of excellent photographs were obtained ; but no trace of the comet's head could be seen while in transit over the sun, although it was carefully sought under favorable atmospheric conditions.

A telegram from Taschkent in Turkestan (Lat. 41° 19′ N., 4^h 37^m E.) is not easy to understand. It reads "Komet Halley 18 Mai 21^h Taschkent durch leicht Wolken auf Sonnenprojection bemerkbar." This seems to say that Halley's Comet could be seen upon the sun's image through light clouds at 9 a.m. May 19. Taschkent M. T. or May 18, 16.23, G. M. T.

The Harvard *Bulletins* report various observations of the tail at or near the time predicted for our passage through it. The tail was visible in the eastern sky at Mt. Hamilton on the morn-

ing of Thursday the 19th. Director Campbell states that the tail was at least 140° long and that it lagged far behind the radius vector. Hence our passage through it would be some time after the transit of the head across the sun's disc. Director Campbell reported that the tail was visible in the east on Friday morning extending through Aquila, one-third as intense as the day before and 1° further north. Similar observations are reported from Worcester, Mass. Rev. Joel H. Metcalf, of Taunton, Mass., is confident that he saw the tail of the comet at 2.45 a.m. on the 20th. It passed through the Square of Pegasus and was 30° wide. Other corroborative reports have been received from Worcester, Mass., Tacubaya, Mexico and Johannisburg, South Africa. Dr. R. H. Curtiss, of the Detroit Observatory, reports that at 2.15 a.m. May 19 he saw a distinct glow which extended from the north point around to the southeast. Extending from this was a definite shaft of light reaching from a bank of clouds below γ Pegasi to the Milky Way. At γ Pegasi, which was in the centre of this glow, this tail was was 12° to 15° wide, tapering rapidly as it rose in the sky, and, at a distance of 15° above γ Pegasi, was about 5° wide. The sky was dark on each side of the light.

Dr. Otto Klotz, of the Dominion Astronomical Observatory, Ottawa, gives on page 227 a report of magnetic observations during transit. A report from the Meteorological Observatory at Toronto, is given on page 229. It seems very doubtful if the phenomena reported have any connection with the transit of the comet. Observations at the University of Toronto for changes in the electrical condition of the atmosphere gave negative results.

I am indebted to Dr. Klotz for copies of communications which he has received from western correspondents regarding some strange phenomena connected with the sunset of Wednesday, May 18.

I shall quote first from a letter from Mr. I. S. Helmcken, dated at Victoria, B. C., May 24 :—

"On Wednesday evening (May 18) about five minutes or so before 7 o'clock, a telephone message came from my niece . . . . . simply stating "look at the sun."

My daughter immediately obeyed, went outside, and called to me, to "come and look at the sun, it is going round and round." I obeyed and at once informed our neighbors on Elliott St. "to come and look at the sun." We numbered six adults and six children, all looking at the same time, with naked eyes, and feelings of dismay or astonishment. My son James subsequently told me that the outside of the sun seemed to revolve like a catharine wheel.

The sunshine light was about as usual, perhaps a little less bright than usual; a cold westerly wind blowing rather roughly; the sky about the sun perfectly clear and blue as usual in Victoria. No fog, no clouds in close proximity to the sun.

The following is what we saw: — The sun appeared to be covered with a dark greyish semi-translucent covering through which the sun, befogged as it were, could be seen behind; the lower border of the sun was pretty clear, surrounding the sun was a rosy colored band. Through occasional cracks in this, bright sunlight appeared, or zigzag flashes of light (like diminutive lightning flashes). From the circumference of the rosy band, now here now there, flashes of various colored (chiefly rosy) flames shot out, something like those of the aurora borealis. These lights gave the idea of a rotary motion. We stared at these phenomena for about twenty minutes, then the orb went down.

I write the above for a record, the writer, although fourscore years and more of age, never having seen anything like it before.

A great many Victorians did not see the extraordinary phenomena related above, but let it be remembered, that at seven o'clock, stores and shops have been already closed; the workmen, etc., have gone to their homes and dinner, and so at this time the streets are in a great measure deserted. Anyhow, there were small crowds of people in various parts of the city looking with awe on the weird phenomena. At how many other places north and south was it seen? or with what variations? What intervened between us and the sun? Halley's Comet was being looked for all over this continent at the time — did this comet in its passage across the sun obscure the sun? Millions were watching and only saw sun spots — did they see the sun spots through the comet?

The difference of time between New York and Victoria is about four hours — from Greenwich, eight hours.

. . . . . .

Living in London, England, when a lad of eight years I must have seen Halley's Comet, but my recollection of its appearance is but dim, but I have always thought, perhaps fancied, that it was much brighter and gave more light than the present one. Of course I saw it from a different position. I saw with naked eyes, the comet on Monday evening, May 23rd, distinctly, and most assur-

edly it had a large tail, which seemed large enough to the naked eye to cover the sun seen under like conditions. Did I and others see the sun spots through the comet's tail?"

Under date May 24, a lady at Birson, Sask., (Lat. about 52° N., Long. 7h W.) writes :—

" . . . . . We have for some time been looking eagerly forward to seeing Halley's Comet make its appearance. Unfortunately there were heavy clouds all day [May 18 O.K.] and until an hour before sun down, they cleared a little sufficient for me to see a very grand sight. The colors were lovely and the appearance and the action of the sun, through the tail of the comet, and the bright circle of light around the sun, together with the beautiful colors extending from the sun, made it certainly one of the most glorious sights one could witness. . . . . "

The JOURNAL would be glad to receive other reports on these phenomena.

C. A. C.

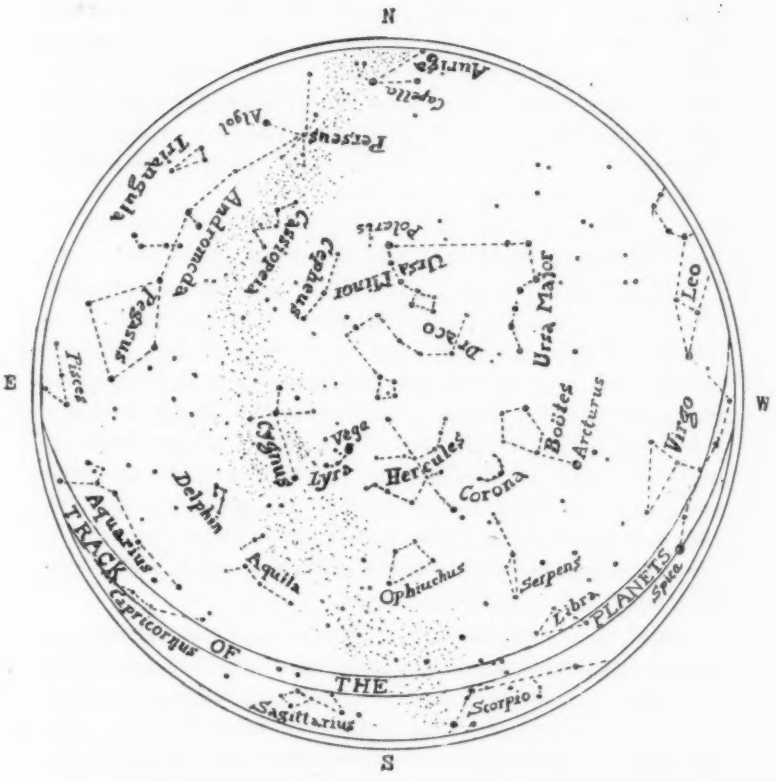
PREDICTIONS FOR JULY AND AUGUST

Constellations on the Meridian in July

Scorpio, the eighth sign and ninth constellation of the zodiac, is of irregular shape. It is only by virtue of two long projections to the north that it is ranked as a zodiac constellation at all, as nearly all the stars belonging to it are some distance south of the ecliptic. The sun spends only nine days out of twenty-five in Scorpio, the other sixteen being occupied in passing through Ophiucus, which, however, is not counted among the zodiac constellations. Scorpio's principal star is Antares, of the first magnitude, color a decided red. Viewed through the telescope Antares color appears interspersed with intermittent flashes of green, which is explained by the presence of a close green companion. Under ordinary atmospheric conditions this companion can not be separated from the rays of Antares itself. At its greatest altitude this star is only about 20° above the southern horizon; passing the meridian at 9 p.m., local time, on July 13.

Ophiucus (The Serpent-Bearer) is situated almost directly above Scorpio; though occupying a considerable space in the sky, is not a very conspicuous constellation. The highest part of this constellation is marked by the star α, of the second magnitude, about half-way between Antares and Vega.

Serpens (The Serpent) is a divided constellation, the principal part being to the north-west of Ophiucus; with one corner to the south-east of the latter. The ancients probably considered it to consist of a trail of stars stretching across, or perhaps coiled



THE CONSTELLATIONS ON AUGUST 1, AT 9 P.M.

The above star-map, as well as the similar ones which have appeared during the last year, have been drawn according to maps which appear in Ball's *Popular Guide to the Heavens*. Messrs. George Philip and Son (London, England), the publishers of this excellent work, very kindly permit the JOURNAL to make reproductions from plates in it.

around, Ophiucus, whence arose the name of the latter. It contains no stars brighter than the third magnitude.

Hercules, a large constellation, is bounded on the north and south by Draco and Ophiucus, and extends east and west nearly from Arcturus to Vega. It has no very conspicuous stars, but contains many good telescopic objects. It is interesting as marking that part of the heavens towards which the solar system is at present travelling. An interesting cluster of 5,000 stars exist in this constellation, known as the Hercules Cluster, which is involved in the letter "u" on the map.

Constellations on the Meridian in August

Lyra though a small constellation, contains several fairly bright stars. The principal of these is Vega, which ranks second or third in the heavens in brightness. Vega is of a brilliant bluish-white color and cannot fail to be easily identified. It crosses the meridian at 9 p.m. on August 15, when it is only a few degrees south of the zenith. This star is always visible at some hour of the night throughout the year. Twelve thousand years from now it will be the pole star, though not so near the Pole as Polaris now is. The other most interesting objects in the constellation are the doubles β and ϵ, the former is also variable, and the annular nebula near β.

Sagittarius (The Archer), the ninth sign and tenth constellation of the zodiac, passes low in the south when Vega is on the meridian. It contains a group of seven fairly bright stars, about 30° to the east of Antares and at about the same altitude. The sun passes through Sagittarius in December and January. The most southerly point of the ecliptic passes through this constellation.

Draco (The Dragon), a very large and winding constellation is in the neighborhood of the Pole, almost completely surrounding Ursa Minor, whose principal object is Polaris. Draco contains several second magnitude stars between Vega and the Pole, and extends westward in a wide curve around Ursa Minor.

Mercury

Mercury will be in superior conjunction with the sun on July 19th and will not be visible until the latter part of August. The planet will be at greatest elongation east of the sun on August 30th. It will then be visible 1 hour after sunset about 27° east of the sun.

Venus

Venus is morning star in the crescent phase, will be in conjunction with Neptune on August 10th about half a degree north of Neptune.

Mars

Mars is a very faint object in Leo, will be at Aphelion July 23rd. On August 6th Mars and Mercury will be in conjunction, Mercury 5′ north.

Jupiter

The planet is well placed for observing. Considerable surface detail can be made out with a good telescope. The belts are unusually conspicuous from the equator to the neighborhood of the polar regions. Consult table on page 252 for identification of satellites and times of their transit and eclipse.

Saturn

Saturn is morning star, will be 90° west of the sun July 29th. The rings are opening out and can be well seen.

Uranus

Uranus will be in opposition 180° east of the sun, in Sagittarius on July 16th. The planet will be on the meridian at midnight on that date.

Neptune

Neptune will be in conjunction with Venus, 28′ north of Venus August 10th.

Double Stars for Small Telescopes

α *Scorpii*. R.A. $16^h\ 23^m{\cdot}3$; Dec. 25° 13′ S. This is the principal star of the constellation. It is of the first magnitude and fiery red like the planet Mars, from which it gets name Antáres, which means "the rival of Mars." Its two components

are of magnitudes 1 and 7, and the distance is 3″·5. It is a beautiful object but requires good atmospheric conditions. It has been seen with a 2¾-inch telescope.

β Scorpii. R. A. 15h 59m·6; Dec. 19° 31′ S., about 8° or 9° northwest of Antares. A triple, with magnitudes 2, 4 and 10. The faint star, which is 0″·9 from the brightest one, was discovered by Burnham in 1879. The distance between the two brighter components is 13″.

ν Scorpii. R. A. 16h 6·m1; Dec. 19° 12′ S., (2° due east of *β*). A quadruple with magnitudes 4, 5, 7, 8. Distance between the two brightest components 0″·8; between 1st and 3rd, 41″; between 3rd and 4th, 2″·4. A beautiful object.

ξ Scorpii. R. A. 15h 58m·9; Dec. 11° 6′ S., (8½° due north from *β*). Triple; magnitudes 5, 5·2, 7·5. From the 1st to 2nd, 1″·4; from 1st to 3rd, 7″·2.

α Herculis. R. A. 17h 10m·1; Dec. 14° 30′ N. A variable star of a yellowish-red color, recognized as such by Herschel in 1795. Changes in brilliancy, not great, and irregular. Double, with magnitudes 3, 6: distance 4″·5. Colors, orange and blue. A beautiful object for a 4-inch telescope.

ρ Herculis. R. A. 17h 20m·2; Dec. 37° 14′ N. Magnitudes 4, 5; distance 4″; white and emerald green. "*ρ* is a gem of a beautiful coronet, in a large field."—*Webb.*

*μ*1 *Sagittarius.* The most familiar configuration in this constellation is the small inverted "milk-dipper" formed by the five stars λ, *φ* *σ*, *τ* and *ζ*. The last four form the bowl while λ, in the Milky Way, is the handle. *μ*1, R. A. 18h 7m·8. Dec. 21° 5′ S., is 7° N. W. of λ, on the line from *ζ* through *φ* produced. A triple, with magnitudes 3·5, 9·5, 10. Distance from 1st to 2nd 40″; from 1st to 3rd, 45″. Burnham has also seen two other faint points of light, making the star really a quintuple.

μ Draconis. R. A. 17h 3m·2; Dec. 54° 36′ N. Magnitudes 4 and 4·5; distance 2″·5. A binary with a probable period of 600 years.

CLUSTERS AND NEBULÆ

Cluster in Scorpio, *M.*80. R. A. $16^h\ 11^m$; Dec. 22° 44′, half-way between α and β. One of the finest clusters known; "the richest and most condensed mass of stars in the firmament."

*M.*4. R. A. $16^h\ 17^m{\cdot}5$; Dec. 26° 17′ S., 1½° west of α Scorpii. Large, rather dim, resolvable. Not so fine as the preceding.

*M.*13. R. A. $16^h\ 38^m{\cdot}1$; Dec. 36° 37′ N. The Great Cluster in Hercules, described in notes in last issue.

M. 20. The Trifid Nebula in Sagittarius. R. A. $17^h\ 56^m{\cdot}3$; Dec. 23° 2′ S. Almost on the line φλ produced. A beautiful and interesting object. "Trifid" means *three-cleft*.

*M.*22, in Sagittarius. R. A. $18^h\ 30^m{\cdot}3$; Dec. 23° 59′ S. A beautiful bright cluster, discovered in 1665, by Abraham Ihle. It is 3° N.W. of λ. A good object for a 4-inch telescope.

*M.*8, in Sagittarius. R. A. $17^h\ 57^m{\cdot}6$; Dec. 24° 22′ S. 7° N. and 1° E. of λ. Visible to naked eye.

Planetary Nebula in Draco. R. A. $17^h\ 58^m{\cdot}6$; Dec. 66° 38′. Like a star out of focus. It is almost exactly at the pole of the ecliptic, about midway between δ and ζ Draconis, but a little nearer ζ. This nebula was discovered by Herschel, February 15, 1786. He describes it as very brilliant, with a disc 35″ in diameter. Can be well seen with 3½-inch refractor. Its spectrum, first seen by Huggins, gives three bright lines. Keeler's photographs with the Crossley Reflector show that the structure is spiral or helical. (See plate 57, Keeler "Memorial Volume," being Vol. VIII. of the *Publications* of the Lick Observatory). Keeler has also shown that this nebula is approaching the sun at the rate of 31 miles per second.

At Greenwich Mean Noon

Date 1910	Day of Year	The Sun's Right Ascension	The Sun's Declination	Equation of Time Subtract from Mean Time	Sidereal Time
		h m s	° ′ ″	m s	h m s
Fri. 1	182	6 38 5·04	N. 23 9 48·0	3 26·8	6 34 38·24
Mon. 4	185	6 50 29·08	22 56 41·4	4 1·16	6 46 27·92
Thur. 7	188	7 2 50·47	22 39 58·6	4 32·88	6 58 17·60
Sun. 10	191	7 15 8·61	22 19 43·3	5 1·34	7 10 7·27
Wed. 13	194	7 27 22·87	21 56 0·0	5 25·92	7 21 56·94
Sat. 16	197	7 39 32·78	21 28 53·7	5 46·16	7 33 46·62
Tues. 19	200	7 51 38·02	20 58 30·5	6 1·73	7 45 36·29
Fri. 22	203	8 3 38·32	20 24 56·5	6 12·36	7 57 25·96
Mon. 25	206	8 15 33·54	19 48 17·8	6 17·91	8 9 15·63
Thur. 28	209	8 27 23·61	19 8 41·1	6 18·31	8 21 5·30
Sun. 31	212	8 39 8·48	18 26 12·9	6 13·51	8 32 54·97

75th Meridian Time, Hours numbering from Midnight

Planetary Phenomena

			Minima of Algol	Configuration of Jupiter's Satellites at 7h 0m
			h m	
	Fri. 1	23h 45m ☌ ♄ ☾, ♄ 0° 23′ S.		432○1
	Sat. 2		9 35	241○3
	Sun. 3	22h·1 ☾ in Perigee.		♃○423
	Mon. 4	0h 55m ☌ ♀ ☾, ♀ 2° 37′ S.; 18h ⊕ in Aphelion.		○243●
	Tues. 5	12h 53m ☌ ☿ ☾, ☿ 3° 8′ S.	6 24	21○34
●	Wed. 6	16h 20m New Moon; 23h 38m ☌ Ψ ☾, Ψ 4° 40′ S.		32○14
	Thur. 7			31○24
	Fri. 8	8h ☿ in ♌; 15h 11m ☌ ♂ ☾, ♂ 3° 52′ S.	3 13	32○14
	Sat. 9			21○4●
	Sun. 10			○1243
	Mon. 11	[Perihelion	0 2	○423●
	Tues. 12	2h ☌ Ψ ☉; 21h 10m ☌ ♃ ☾, ♃ 2° 58′; 23h ☿ in		421○3
	Wed. 13		20 51	432○1
☽	Thur. 14	3h 24m·4 First Quarter.		431○2
	Fri. 15	19h ☾ in Apogee.		♃43○1
	Sat. 16	3h ☌ ☿ Ψ, ☿ 1° 54′ N.; 11h ☍ ♅ ☉.	17 30	421○●
	Sun. 17			4○123
	Mon. 18			41○23
	Tues. 19	11h ☌ ☿ ☉ Superior.	14 19	♃24○3
	Wed. 20			32○14
	Thur. 21	16h 6m ☌ ♅ ☾, ♅ 3° 44′ N.		31○24
○	Fri. 22	3h 37m Full Moon.	11 8	3○214
	Sat. 23	0h ♂ in Aphelion; 6h ☿ Greatest Hel. Lat. N.		213○4
	Sun. 24			○134●
	Mon. 25		7 57	1○234
	Tues. 26			♃2○34
	Wed. 27			23○4●
	Thur. 28		4 46	314○2
☾	Fri. 29	4h 34m·5 Last Quarter; 6h 28m ☌ ♄ ☾, ♄ 0° 52′ S.		34○21
	Sat. 30	17h·4 ☾ in Perigee; 2h □ ♄ ☉.		4213○
	Sun. 31		1 35	4○13●

Key to Symbols.—☌ Conjunction; ☍ Opposition; □ Quadrature; ☊ Ascending Node; ☋ Descending Node; ☉ Sun; ☿ Mercury; ♀ Venus; ⊕ Earth; ♂ Mars; ♃ Jupiter; ♄ Saturn; ♅ Uranus; Ψ Neptune.

At Greenwich Mean Noon

Date 1910	Day of Year	The Sun's Right Ascension	The Sun's Declination	Equation of Time Subtract from Mean Time	Sidereal Time
		h m s	° ′ ″	m s	h m s
Mon. 1	213	8 43 2·27	N. 18 11 26·8	6 10·74	8 36 51·53
Thur. 4	216	8 54 40·06	17 25 21·9	5 58·86	8 48 41·20
Sun. 7	219	9 6 12·46	16 36 43·8	5 41·60	9 0 30·87
Wed. 10	222	9 17 39·41	15 45 40·7	5 18·93	9 12 20·53
Sat. 13	225	9 29 1·13	14 52 21·6	4 50·93	9 24 10·20
Tues. 16	228	9 40 17·07	13 56 54·9	4 17·81	9 35 59·87
Fri. 19	231	9 51 29·35	12 59 29·2	3 39·82	9 47 49·53
Mon. 22	234	10 2 36·54	12 0 12·7	2 57·34	9 59 39·20
Thur. 25	237	10 13 39·70	10 59 13·4	2 10·84	10 11 28·86
Sun. 28	240	10 24 29 26	9 56 39·3	1 20·74	10 23 18·52
Wed. 31	243	10 35 35·64	8 52 38·5	0 27·46	10 35 8·18

		75th Meridian Time, Hours numbering from Midnight Planetary Phenomena	Minima of Algol	Configuration of Jupiter's Satellites at 20h 0m
			h m	
	Mon. 1			41○23
	Tues. 2	18h 18m ☌ ♀ ☾, ♀ 4° 7′ S.	22 24	42○13
	Wed. 3	9h 58m ☌ ♆ ☾, ♆ 4° 45′ S.		♃421○
	Thur. 4			341○2
●	Fri. 5	1h 36m·8 New Moon.	19 13	34○12
	Sat. 6	1h ☌ ☿ ♂, ☿ 0° 5′ N.; 7h 50m ☌ ♂ ☾, ♂ 4° 1′ S.;		231○4
	Sun. 7	[8h 26m ☌ ☿ ☾, ☿ 4° 7′ S.		2○314
	Mon. 8		16 2	1○234
	Tues. 9	13h 26m ☌ ♄ ☾, ♄ 2° 34′ S.		2○134
	Wed. 10	20h ☌ ♀ ♆, ♀ 0° 28′ N.		21○34
	Thur. 11		12 51	♃3○24
☽	Fri. 12	21h 1m·1 First Quarter; ☾ in Apogee.		3○124
	Sat. 13			321○4
	Sun. 14	15h ☿ in ♌.	9 40	24○31
	Mon. 15	17h ☿ in ♍.		41○23
	Tues. 16			♃4○13
	Wed. 17	22h 45m ☌ ♋ ☾, ♋ 3° 46′ N.	6 29	421○3
	Thur. 18			43○12
	Fri. 19			43○2●
☍	Sat. 20	14h 14m·1 Full Moon; 4h ♄ Stationary.	3 18	4321○
	Sun. 21			42○31
	Mon. 22			14○23
	Tues. 23		0 7	○2143
	Wed. 24	20h·2 ☾ in Perigee.		21○34
	Thur. 25	12h 45m ☌ ♄ ☾, ♄ 1° 18′ S.; 22h ☿ in Aphelion.	20 56	3○14●
	Fri. 26			31○24
☾	Sat. 27	9h 33m·2 Last Quarter.		♃32○4
	Sun. 28		17 45	23○14
	Mon. 29			1○234
	Tues. 30	18h ☿ Greatest Elongation E. 27° 14′; 18h 8m ☌ ♆ ☾,		○2413
	Wed. 31	[♆ 4° 56′ S.	14 34	214○3

For Jupiter's Satellites, the circle ○ represents the disc of the planet; ♃ signifies that the satellite is on the disc; ● signifies that the satellite is behind the disc or in the shadow. Configurations are for an inverting telescope.

The August Meteors

The best marked of the minor showers occurs about August 9th or 10th of each year. The radiant point is in the constellation Perseus. By watching the eastern heavens toward midnight on the 9th or 10th of August of any year, it will be seen that innumerable meteors move from north-east towards south-west, having often the distinctive characteristic of leaving a trail behind, which, however, vanishes in a few moments. Assuming their orbits to be parabolic, the elements were calculated by Schiaparelli, of Milan, and, on comparing with the orbits of observed comets, it was found that these meteoroids moved in nearly the same orbit as the second comet of 1862. The exact period of this comet is not known, although its orbit is certainly elliptic. According to the best calculation, it is 124 years, but it may be uncertain by ten years or more.

There is one remarkable difference between the August and the November meteors. The latter appear for two or three consecutive years, and then are not seen again until about thirty years have elapsed. But the August meteors are seen every year. This shows that the stream of August meteoroids is endless, every part of the orbit being occupied by them, while in the case of the November ones they are gathered into a group.—Newcomb's *Astronomy for High Schools and Colleges.*

ECLIPSES AND TRANSITS OF THE SATELLITES OF JUPITER

E = eclipse, O = occultation, T = transit, S = shadow, D = disappearance, R = re-appearance, I = ingress, e = egress.

Eastern Standard Time; hours numbering from midnight.

JULY

d	h	m			d	h	m			d	h	m		
3	20	47	I.	TI	**9**	22	30	III.	ER	**19**	20	22	I.	SI
	22	3	I.	SI	**10**	22	43	I.	TI		21	25	I.	TI
	23	2	I.	Te	**12**	20	41	I.	Se	**26**	21	7	I.	TI
4	21	23	I.	ER	**15**	22	19	II.	SI	**27**	20	34	II.	Se
6	23	1	II.	OD	**16**	21	53	III.	OR		21	37	I.	eR
8	22	23	II.	Se	**17**	20	5	II.	ER	**31**	20	23	II.	OD
9	20	27	III.	ED	**18**	21	48	I.	OD					

AUGUST

d	h	m			d	h	m			d	h	m		
3	20	14	I.	OD	**9**	20	4	II.	Te	**12**	19	56	I.	eR
	20	22	III.	Te	**11**	19	34	I.	TI	**16**	20	6	II.	TI
4	19	50	I.	Te		20	35	I.	SI	**18**	19	42	II.	eR
	20	54	I.	Se										